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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.

VOL. CII.—No. 2641.] *LONDON: FRIDAY, AUGUST* 11, 1916. [*Registered at the General Post Office as a Newspaper.*] [PRICE...6d. BY INLAND POST...8d.

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SESSION 1916-1917.

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F. H. PRUEN, M.A., Secretary.
Armstrong College, Newcastle-upon-Tyne. 5353

University of London. University College.

SESSION 1916-1917.

FACULTY OF ENGINEERING.

The SESSION BEGINS on MONDAY, OCTOBER 2nd.

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Students desirous of entering the Faculty of Engineering with a view to taking a full Degree or Diploma Course must have passed the Matriculation Examination, or some other Examination accepted in its stead.

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Students who have already undergone a partial training elsewhere, and who have attained a sufficient standard, may enter for a Course occupying less than three years, and may obtain a General Certificate of Engineering after not less than two consecutive Sessions' attendance.

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Full particulars may be obtained on application to the undersigned.
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Northampton Polytechnic Institute, St. John Street, London, E.C.

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The Fees are £20 per annum.

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(By Order) T. DUNCOMBE MANN,
9th August, 1916. Clerk to the Board.

APPOINTMENTS OPEN.

PORTSMOUTH MUNICIPAL COLLEGE.

APPOINTMENT OF HEAD OF THE MECHANICAL AND CIVIL ENGINEERING DEPARTMENT.

The Education Committee invite

Applications for the Position

of HEAD of the Mechanical and Civil Engineering Department of the Portsmouth Municipal College.

Salary: £225 increasing by £12 10s. per annum to £250.

Full particulars and Form of Application will be forwarded on receipt of stamped addressed foolscap envelope.

Applications, accompanied by copies only of three recent testimonials must be received not later than Wednesday, the 23rd August, 1916, addressed to the SECRETARY for Higher Education, the Municipal College, Portsmouth. E 766

COUNTY BOROUGH OF BARROW-IN-FURNESS.

TECHNICAL SCHOOL.

The Education Authority for the Borough require the

Services of a Principal for

the Technical School.

The gentleman appointed must be specially qualified in Engineering subjects, and ineligible for Military Service, will be required to undertake (under the direction of the Director of Education) the organisation and management of all departments of the Technical School, to take part in the instruction there given, and to advise, when required, on the preparatory Technical work undertaken in the Evening Continuation Schools.

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Applications, furnishing particulars of professional and technical training, experience in teaching and organisation, together with copies of three recent testimonials, references, &c., should be forwarded to the Director of Education, Town Hall, on or before the 2nd September, 1916, and be endorsed "Principal of Technical School."

By Order,
L. HEWLETT,
Town Clerk and Clerk to Local Education Authority.
Town Hall, Barrow-in-Furness,
27th July, 1916. E744

RUTHERFORD MUNICIPAL TECHNICAL COLLEGE, NEWCASTLE-UPON-TYNE.

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PERCIVAL SHARP,
Director of Education.
Education Office, Northumberland Road, Newcastle-upon-Tyne.
9th August, 1916. E 826

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THE LUBRICATION OF GEAR-TEETH.

THE success of modern high-speed reduction gears is undoubtedly due to the efficiency of the lubrication. The teeth rapidly acquire a fine surface and then cease to wear appreciably.

The theory of lubrication as worked out by Osborne Reynolds for bearings appears to be at least equally applicable to the lubrication of high-speed gearing. The absence of wear must be attributed to the presence of an oil film between the teeth, and as the bearing of the teeth on each other is very narrow, there can be no appreciable motion of the oil parallel to the line of contact, the whole flow taking place in the direction of the relative motion of the two surfaces. This was the assumption made by Osborne Reynolds; but in ordinary bearings there is undoubtedly a good deal of end flow parallel to the axis of the journal, a condition of things which to some extent limits the practical application of the theory. For the reason already given, there can be very little flow of this kind in the case of gear-teeth.

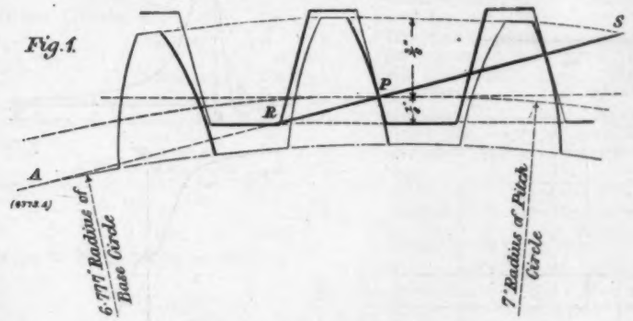
With the proportions and type of teeth usual in such gears, the motion of the teeth relatively to each other is mainly one of rolling, the slip being only a fraction of the roll.

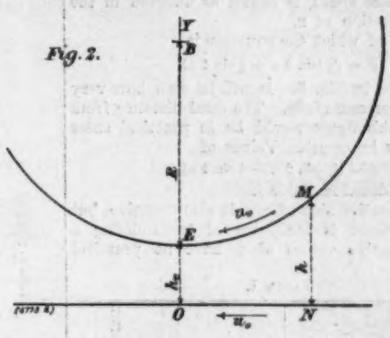
Referring to Fig. 1, which has been drawn (on a slightly enlarged scale) for a pinion 14 in. in diameter, and with 54 teeth gearing with a rack, the length of the active face of the pinion tooth, with the proportions shown, is 0.6108 in., whilst the effective length of the corresponding surface of the rack tooth is 0.4289 in. As will be seen, the height of the rack tooth above the pitch line has been made only one-third of that of the pinion tooth. In fact, so far as lubrication is concerned, the less the rack tooth extends beyond the pitch line the better, since with involute teeth the curvature of the pinion teeth becomes sharper the nearer the base circle is approached. At the limit, of course, the curvature becomes infinite. It is sufficiently obvious, from general considerations, that the sharper the curvature of two surfaces in contact the greater the intensity of the pressure between them, and the greater the liability to abrasion. With the proportions shown in Fig. 1, the pinion never makes contact with a radius of less than A R, which is 1.2535 in.

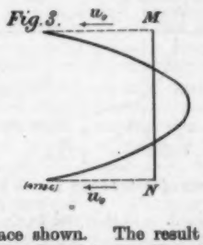
As will be shown later, the intensity of the pressure varies as the square root of the radius of curvature, so that, with an equal thickness of oil film, the maximum pressure reached will be greater the sharper the curvature. The maximum radius of curvature of the pinion teeth, in the case taken, is represented by A S, which is 2.9067 in., and the mean radius of curvature of the active portion of the tooth is 2.749 in. as determined by one of Cote's formulæ for approximate integration. In the case of gears with helical teeth it is this mean radius of curvature which affords the best basis for comparison. A further extension of the pinion tooth above the pitch line would still further increase this mean radius of curvature, but it would, of course, increase also the maximum bending moment on the teeth, and also the percentage of slip. The more nearly the relative motion of the teeth approximates to pure rolling the more effective is the lubrication.

In the case represented in the figure, the angle of obliquity of the teeth is 14½ deg. Speaking at the Engineers' Club, Philadelphia, in 1893, Mr. W. Lewis advocated the increase of this angle to 22½ deg. Such a change in the gear under consideration would increase both the least radius of curvature and also the mean radius of curvature. Hence the increase of the angle as suggested would reduce the intensity of the pressure. On the other hand, the slip would be increased, and the number of teeth in gear for a given length of the path of contact would be diminished. The relative speed of the two surfaces with the same pitch-line speed would be raised considerably, so that the effective drag on the oil would be increased. On the whole, however, it is perhaps better that the angle the path of contact makes with the tangent should be small rather than large, but, as will be seen, there are points on both sides.

Osborne Reynolds gave the solution of the problem of lubrication when one surface slipped over the other, and it is easy to modify his solution to meet the case in which the relative motion of the two surfaces is one of rolling rather than sliding. In that case the two surfaces have the same speed. Suppose then that in Fig. 2 we have a roller of radius R, revolving with a surface speed u_0, and that at a little distance below it there is a plane surface moving to the left with the same speed. If these two surfaces are covered with oil, they will drag this oil along with them, crowding it into the constantly narrowing space shown. The result will be that a pressure is developed in the film of oil, between the roller and the plane surface below it, and, as will be shown in the sequel, this pressure may attain a value of some tons per square inch, though, of course, this intensity is confined to an exceedingly narrow band.







In ENGINEERING, vol. c., pages 101, *et seq*, we gave in detail the derivation of the equations to the flow of a viscous fluid, which served as the starting point for Osborne Reynolds's theory. If the fluid be assumed as incompressible, these equations are:—

$$\frac{dP}{dx} = \mu \nabla^2 u \quad . \quad . \quad . \quad . \quad (1)$$

$$\frac{dP}{dy} = \mu \nabla^2 v \quad . \quad . \quad . \quad . \quad (2)$$

$$\frac{dP}{dz} = \mu \nabla^2 w \quad . \quad . \quad . \quad . \quad (3)$$

where P denotes the pressure of the oil, μ its viscosity, whilst u, v and w denote the velocities of flow parallel to the axes of X, Y and Z respectively.

In the case under consideration both v and w can be considered to be zero, and u, moreover, does not vary with z. Hence the above three equations reduce to:—

$$\frac{dP}{dx} = \mu\left(\frac{d^2u}{dx^2} + \frac{d^2u}{dy^2}\right) \quad . \quad . \quad (4)$$

Further, the rate of variation of u with x is relatively very slow, so that $\frac{d^2u}{dx^2}$ can be neglected in comparison with $\frac{d^2u}{dy^2}$.

We may therefore, following Reynolds, write as our finally simplified equation:—

$$\frac{dP}{dx} = \mu \frac{d^2u}{dy^2} \quad . \quad . \quad . \quad (5)$$

Now if v be zero, equation (2) above shows that P cannot be a function of y. This is also obvious from general considerations, as in a thin film the pressure at any point on the roller must be sensibly the same as that at a point on the plate immediately under it. Hence (5) can be integrated in the form:—

$$u = \frac{1}{2\mu}[y^2 - hy]\frac{dP}{dx} + u_0 \quad . \quad . \quad (6)$$

Here h denotes the distance between the two surfaces at any point. At each surface the speed of the oil is the same as that of the surface, and in agreement with this (6) shows that $u = u_0$ both when $y = 0$ and when $y = h$.

If in Fig. 2 we draw the vertical line MN, then as much oil must pass out past the section EO as enters past the section MN. In fact, the velocity curve at the latter section has some such shape as indicated in Fig. 3, so that near mid-height the direction of the flow is reversed. Expressed mathematically, this condition of equality of flow is equivalent to:—

$$\int_0^h u\,dy = C.$$

If, therefore, we integrate (6) between $y = 0$ and $y = h$, remembering that P is not a function of y, we get:—

$$C = -\frac{1}{12\mu}h^3\frac{dP}{dx} + u_0 h,$$

which on re-arrangement gives:—

$$\frac{1}{12\mu}\frac{dP}{dx} = \frac{u_0}{h^2} - \frac{C}{h^3}.$$

Now h denotes the height of the surface of the roller above the flat plate. The equation to this surface is:—

$$[2R - h + h_0][h - h_0] = x^2,$$

which, if we neglect the square of $[h - h_0]$, which is always very small in the neighbourhood of the point of contact, gives:—

$$h = h_0\left[1 + \frac{x^2}{2Rh_0}\right]$$

Making this substitution gives:—

$$\frac{1}{12\mu}\frac{dP}{dx} = \frac{u_0}{h_0^2}\frac{1}{\left(1 + \frac{x^2}{2Rh_0}\right)^2} - \frac{C}{h_0^3\left[1 + \frac{x^2}{2Rh_0}\right]^3}$$

It is convenient to put:—

$$\frac{C}{h_0^3} = \frac{u_0}{h_0^2}L,$$

where L is a constant, the value of which will be determined later. Taking this value of C, we get:—

$$\frac{1}{12\mu}\cdot\frac{dP}{dx} = \frac{u_0}{h_0^2}\cdot\left[\frac{1}{\left(1 + \frac{x^2}{2Rh_0}\right)^2} - \frac{L}{\left(1 + \frac{x^2}{2Rh_0}\right)^3}\right] \quad (7)$$

From this equation we note that since P will be a maximum when $\frac{dP}{dx} = 0$, the maximum pressure will occur for some value of x, such that

$$\frac{x^2}{2Rh_0} = L - 1.$$

By substituting $\tan\alpha = \dfrac{x}{\sqrt{2\,R\,h_0}}$, (7) can be integrated in the form :—

$$\frac{1}{12\,\mu}\,P = \frac{u_0}{h_0^2}\sqrt{2\,R\,h_0}\times$$
$$\left[A + \frac{\alpha}{2} + \frac{\sin 2\alpha}{4} - L\left(\frac{3\alpha}{8} + \frac{\sin 2\alpha}{4} + \frac{\sin 4\alpha}{32}\right)\right]$$

When $x = \infty$ the pressure is zero. Inserting this condition gives :—

$$\frac{P}{12\,\mu} = \frac{u_0}{h_0^2}\left\{\frac{\alpha}{2} + \frac{\sin 2\alpha}{4} - \frac{\pi}{4} - L\left[\frac{3\alpha}{8} - \frac{3\pi}{16} + \frac{\sin 2\alpha}{4} + \frac{\sin 4\alpha}{32}\right]\right\} \quad . \quad (8)$$

To determine L we note that when the pinion tooth just begins to engage with the rack tooth, the conditions are as represented in Fig. 4. In that case the pressure is 0 when $x = 0$. This is an unfavourable condition, since in such a case as is represented in Fig. 2 the region of pressure extends to the left of O E. Taking it, however, as one possible case, we note that when $x = 0$, α is also 0, so that putting $P = 0$ in (8) with this value of α gives $L = \frac{4}{3}$.

With this value of L we get :—

$$\frac{P}{12\,\mu} = -\frac{u_0}{h_0^2}\cdot\frac{\sqrt{2\,R\,h_0}}{12}\cdot[\sin 2\alpha + \tfrac{1}{2}\sin 4\alpha].$$

The minus sign appears because, as drawn in Fig. 2, u_0, the surface speed, is shown as directed in the negative direction of x.

The curve of which the equation is

$$\phi = \tfrac{1}{12}(\sin 2\alpha + \tfrac{1}{2}\sin 4\alpha)$$

is represented in Fig. 5. It will be seen how very rapidly the pressure falls. The total distance from 0 to 10 in this figure would be in practical cases $\frac{1}{2}$ in. or less in length. Values of

$$\phi = \tfrac{1}{12}(\sin 2\alpha + \tfrac{1}{2}\sin 4\alpha)$$

are also tabulated in Table I.

On the negative side of x, ϕ is also negative, but as the lubricant is incapable of transmitting a tension, negative values of ϕ have no practical importance.

Table I.

$\frac{x}{2\sqrt{R\,h_0}} = \tan\alpha$.	$\phi = \frac{1}{12}\left\{\frac{\sin 2\alpha + \sin 4\alpha}{2}\right\}$.	$\theta = \frac{1}{8}\left\{\frac{\pi}{2} - \alpha + \frac{\sin 4\alpha}{4}\right\}$.	$\psi = 0{\cdot}67725\,\phi + 0{\cdot}32275\,\theta$ when $\frac{x}{\sqrt{2\,R\,h_0}} = -0{\cdot}47517$.
− 0.5	− 0.10667	0.22431	0.000155
− 0.4	− 0.09908	0.21270	0.00154
− 0.3	− 0.08417	0.20406	0.00885
− 0.2	− 0.06163	0.19883	0.02244
− 0.1	− 0.03266	0.19668	0 04135
0.0	0.00000	0.19635	0.06337
0.1	0.03266	0.19602	0.08538
0.2	0.06163	0.19387	0.10430
0.3	0.08417	0.18964	0.11788
0.4	0.09908	0.18000	0.12519
0.5	0.10667	0.16839	0.12656
0.6	0.10813	0.15474	0.12317
0.7	0.10510	0.14011	0.11639
0.8	0.09915	0.12540	0.10762
0.9	0.09158	0.11129	0.09794
1.0	0.08333	0.09818	0.08812
1.5	0.04734	0.05132	0.04862
2.0	0.02667	0.02796	0.02708
2.5	0.01585	0.01626	0.01601
3	0.01000	0.01022	0.01007
4	0.00589	0.00467	0.00549
5	0.00246	0.00253	0.00239
6	0.00146	0.00147	0.00146
7	0.00093	0.00094	0.00936
8	0.00063	0.00063	0.00632
9	0.00045	0.00045	0.00445
10	0.00028	0.00033	0.00029

If the value of L be made less than $\frac{4}{3}$, but greater than 1, we get a curve of the general character shown in Fig. 6. Here the curve cuts the axis of x to the left of the origin at B, and later on at C. The positive portion of this curve lies everywhere outside of ϕ, as already plotted in Fig. 5, so that a greater load can be carried with a given thickness of oil film. The maximum is attained when the two points B and C coincide. The curve then touches the axis of X without cutting it. The distance of this point of contact from 0 is given by the relation :—

$$\tan\alpha = \frac{x}{\sqrt{2\,R\,h_0}} = -0.47517,$$

and the value of L is 1.2258. If we denote this curve by ψ, then the pressure at any point is given by

$$P = \frac{12\,\mu\,u_0}{h_0^2}\sqrt{2\,R\,h_0}\,.\,\psi.$$

Values of ψ are given in the fourth column of Table I.

If we take L as unity, we get :—

$$\frac{1}{12\,\mu}\,.\,P = -\frac{u_0}{h_0^2}\frac{\sqrt{2\,R\,h_0}}{8}\left[\frac{\pi}{2} + \alpha - \frac{\sin 4\alpha}{4}\right]$$

The curve thus expressed has a point of inflexion when $x = 0$, and its general character is shown in Fig. 7. It does not correspond to any practical case of lubrication, but if we denote

$$\frac{1}{8}\left[\frac{\pi}{2} + \alpha - \frac{\sin 4\alpha}{4}\right]$$

by θ, then every possible pressure curve (subject to the condition that the pressure is zero at infinity) is given by :—

$$\frac{1}{12\,\mu}\,P = -\frac{u_0}{h_0^2}\sqrt{2\,R\,h_0}\left[(1-y)\,\theta + y\,\phi\right]$$

For the curve which we have denoted by ψ, y has the value 0.67725. Values of θ are given in the third column of Table I.

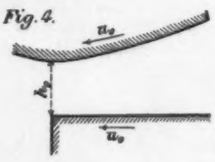


Fig. 4.

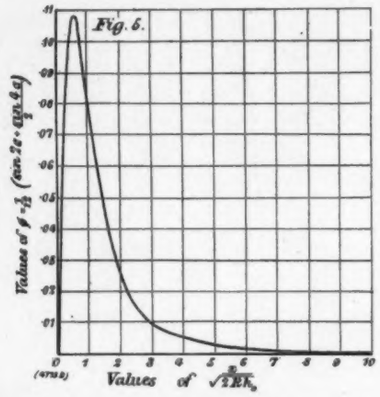


Fig. 5.

The total area of θ between $x = 0$ and $x = +\infty$ is easily obtained. It is equal to $\dfrac{\sqrt{2\,R\,h_0}}{4}$.

Similarly, the integral of ϕ between the same limits is $\dfrac{\sqrt{2\,R\,h_0}}{6}$, whilst the value of ψ between $x = -\sqrt{2\,R\,h_0} \times 0.47517$, and $x = \infty$ is $0.2040\,\sqrt{2\,R_0\,h}$, or a little over $\dfrac{\sqrt{2\,R\,h_0}}{5}$.

With this latter curve the load carried with a given thickness of oil film is a maximum. This total load is, of course :—

$$\int_{-a}^{\infty} P\,dx = -\frac{12\,\mu\,u_0}{h_0^2}\sqrt{2\,R\,h_0}\times\sqrt{2\,R\,h_0}\times 0.2040$$
$$= -\frac{24\,\mu\,u_0\,R\times 0.2040}{h_0}$$
$$= -4.896\,\frac{\mu\,u_0\,R}{h_0}\text{ dynes per cm. run} \quad . \quad (9)$$

The maximum pressure is attained when

$$x = 0.47517\sqrt{2\,R\,h_0},$$

and its value is

$$P_{max.} = \frac{12\,\mu\,u_0}{h_0^2}\sqrt{2\,R\,h_0}\times 0.12673$$
$$= 1.521\,.\,\frac{\mu\,u_0}{h_0^2}\,.\,\sqrt{2\,R\,h_0}\text{ dynes per sq. cm.} \quad . \quad (10)$$

These expressions apply to a pinion gearing with a rack. If, however, it gears with a wheel we must replace R by ρ, where :—

$$\frac{1}{\rho} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right).$$

In this expression R_1 denotes the radius of curvature of the pinion tooth, and R_2 that of the wheel tooth.

From data for which the writer is indebted to the Power Plant Company, Limited, of West Drayton, Middlesex, it appears that the lubricant they recommend for turbine gears is a pure mineral oil, with a viscosity of 2.3 to 2.5 dynes per sq. cm. at 60 deg. Fahr., which diminishes to 0.65 to 0.75 dynes per sq. cm. at 100 deg. Fahr. The temperature of the oil, with the gears running, may, they state, be taken as 90 deg. to 100 deg. Fahr., so that the value of μ in the expression above given may be taken as 0.7 dyne per sq. cm. The equations found apply in strictness only to straight teeth, but may be used at least as a first approximation for helical teeth.

Suppose the gear to have teeth as represented in Fig. 1. The pitch is, as stated, 0.822 in., and teeth of this pitch, but on a smaller pinion, have been successfully used to carry a load of 520 lb. per in. of effective pinion length at a pitch-line speed of 62 ft. per second, the angle of the helix being very nearly 45 deg.

We can, from equation (9) above, determine the

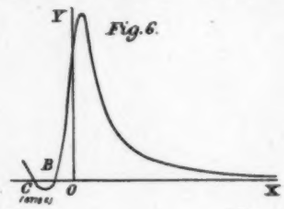


Fig. 6.

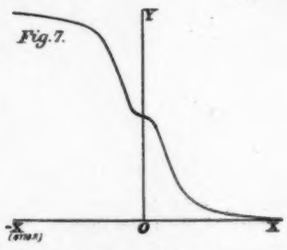


Fig. 7.

thickness of the oil film, and from equation (10) the maximum pressure between the opposing surfaces.

In helical gears each tooth is in bearing over a distance corresponding to the length of the path of contact. If l be the length of this path of contact when projected on the pitch line, and p the pitch, the load will be divided between $\dfrac{l}{p}$ teeth. In the present case $l = 1.600$, and $p = 0.822$; therefore the load per lineal inch of the helical teeth will be $\dfrac{520\times 0.822}{1.600} = 267$ lb. per lineal inch, or 105 lb. per cm. run. Converting this load into dynes gives 470×10^5 dynes per cm. run nearly.

With a pitch-line speed of 62 ft. a second, the mean speed with which the teeth roll over each other will be 20.3 ft. per second, or, say, 618 cm. per second.

The mean radius of curvature of the pinion tooth is 2.749 in., = say 7 cm. Hence equation (9) gives :—

$$470 \times 10^5 = \frac{4.896 \times 0{\cdot}7 \times 618 \times 7}{h_0}$$

Whence the thickness of the oil film

$$h_0 = \frac{1}{3171}\text{ cm. or }\frac{1}{8050}\text{ in.}$$

With this value of h_0 we get $\sqrt{2\,R\,h_0} = 0.06647$ cm., whence from (10) :—

$$P_{max.} = 1.521\times 0.7\times 618\times 0.06647\times(3171)^2\text{ dynes per sq. cm.}$$
$$= 6376\text{ lb. per sq. in.}$$

The effective length of the bearing of the teeth on each other extends on the negative side of h_0 to

$$0.0665 \times 0.47517 = 0.0316\text{ cm.}$$

On the positive side the pressure falls to less than $1\frac{1}{13}$ of its maximum value, at a distance equal to

$$3 \times 0.665 = 0.1995\text{ cm.}$$

The whole bearing is thus, for practical purposes, confined to a width of, say, 0.22 cm. = 0.0866 in.

It will be seen that for all practical purposes the

pressure vanishes at a very short distance from the point of contact, though we have assumed that it only becomes absolutely zero at ∞. This assumption is therefore justified, as there would be no material alteration in the pressures if the pressure were assumed to vanish at a finite distance from the point of contact.

It may be noted that when the driving face of a tooth is on the point of ceasing contact, lubrication will be very imperfect. An easing off of the tooth for the last $\frac{1}{30}$ in. of its height would apparently be of some advantage.

It is also possible to calculate from Osborne Reynolds's theory the frictional losses. The drag on each square centimetre of the surfaces acting is equal to $\mu \left.\frac{d\,u}{d\,y}\right]_0$ dynes per sq. cm., where u denotes the velocity of the fluid and $\left.\frac{d\,u}{d\,y}\right]_0$ the value of $\frac{d\,u}{d\,y}$, when $y = 0$. If the surface is moving with a velocity u_0, then the work done per second is:—

$$u_0 \mu \left.\frac{d\,u}{d\,y}\right]_0 \text{ ergs.}$$

From equation (6) *ante* we have:—

$$u = \frac{1}{2\,\mu} \cdot \left[u^2 - h y\right] \frac{d\,P}{d\,x} + u_0$$

$$\therefore \left.\frac{d\,u}{d\,y}\right]_0 = -\frac{1}{2\,\mu} \cdot h \frac{d\,P}{d\,x}.$$

Whence from (7) *ante*:—

$$\left.\frac{d\,u}{d\,y}\right]_0 = -\frac{6\,u_0}{h_0}\left\{\frac{1}{1+\frac{x^2}{2\,R\,h_0}} - \frac{L}{\left[1+\frac{x^2}{2\,R\,h_0}\right]^2}\right\}$$

Hence if $d\,W$ be the work done on both of the two acting surfaces, on a section 1 cm. wide and $d\,x$ cm. long, we get:—

$$d\,W = 2\,u_0\,\mu \left.\frac{d\,u}{d\,y}\right]_0 d\,x$$

$$= -\frac{12\,u_0^2\,\mu}{h_0} \cdot \left[\frac{1}{1+\frac{x^2}{2\,R\,h_0}} - \frac{L}{\left(1+\frac{x^2}{2\,R\,h_0}\right)^2}\right] d\,x.$$

This can be integrated by substituting:—

$$\tan \alpha = \frac{x}{\sqrt{2\,R\,h_0}}$$

so that

$$\int_a^\infty d\,W = \frac{12\,u_0^2\,\mu\,\sqrt{2\,R\,h_0}}{h_0}\left(\frac{\pi}{2} - \alpha + L\left(\frac{\alpha}{2} + \frac{\sin 2\,\alpha}{4} - \frac{\pi}{4}\right)\right)$$

Taking $L = 1.2258 \times a = -0.4752$, we get:—

$$W = \frac{12.35 \cdot u_0^2\,\mu\,\sqrt{2\,R\,h_0}}{h_0} \text{ ergs per second per cm. run.}$$

Taking, as before, $u_0 = 618$, $\mu = 0.7$, $\sqrt{2\,R\,h_0} = 0.06647$, and $h = \frac{1}{3171}$ cm., we get:—

$$W = 12.35 \times 618^2 \times 0.7 \times 0.06647 \times 3171.$$
$$= 6.96 \times 10^6 \text{ ergs per second.}$$
$$= 69.6 \text{ joules per cm. run.}$$
$$= 177 \text{ joules per second per inch run.}$$

Since, however, the equivalent of 1.95 teeth is always in action, the total loss will be 345 joules per inch run of tooth, or, say, 500 joules per inch of length of pinion.

The useful work done per inch of width per second is $520 \times 62 = 32{,}240$ ft.-lb. $= 43{,}800$ joules.

The loss is therefore about 1.14 per cent. This figure is in good agreement with actual experience.

It will be seen that for a given value of h_0 the maximum pressure attained is proportional to the square root of the diameter of the pinion. Hence, so far as security against abrasion is concerned, it would seem that the permissible load per inch of pinion length will vary with the square root of the pinion diameter; whilst if the bending stress on the teeth is considered, the permissible load will vary as the pinion diameter.

In practice the teeth of pinions with fixed bearings appear to bear uniformly all over, in spite of the deformation due to the torque transmitted. Apparently this is to be attributed to the fact that the pinion "floats" on the oil films between its journals and the brasses.

SIBERIAN IRON ORE.—Recent surveys of the iron deposits of the basin of the Telbesa and the Temir Tau district in Siberia result in aggregate estimates of 20,000,000 tons of iron ore. A large proportion of the deposits yield 55 per cent. of iron.

THE ARRANGEMENT OF MACHINE SHOPS.—No. II.

By JOSEPH HORNER.

THE illustrations accompanying the present article show the general design and lay-out of the machine shop built by Messrs. Petters, Limited, of Yeovil, in 1911. This firm manufactures only one speciality in various sizes, namely, internal-combustion engines using oil or gas, including the semi-Diesel design. A few notes on these engines may precede the account of the shops.

The oil engines (Otto cycle) are built in a very large range of dimensions to use any brands of oil, the crude oils, paraffin, kerosene, "Royal Daylight" or "Rocklight" oils. The consumption of common paraffin lamp oil in these engines at full load under ordinary working conditions does not exceed ¾ pint per brake horse-power per hour, rather less in larger engines, and rather more in smaller ones. The oil is contained in a tank, and flows to the engine through a control valve, the supply being regulated by a centrifugal ball governor, which graduates the opening in an oil inlet valve, and a throttle on the air inlet. The result is that the proportions of oil and air remain constant, though the quantities vary. The ignition is by a lampless tube vaporizer (hot bulb). This being first warmed by a blow lamp retains its heat by the action of the exhaust playing on it. The tube is protected by an enclosing box. Water injection apparatus is fitted. The semi-Diesel engines working on crude oil on the two-stroke cycle are built in one, two, three, and four-cylinder types. The governing and the vaporizer are designed similarly to those of the oil engines just noted. The oil consumption of Scotch shale or Russian naphtha on working load does not exceed 0.5 pint per brake horse-power per hour.

The firm was founded only 20 years ago, in a small shop which is now surrounded by the buildings that have grown up rapidly around it. Though these, the Nautilus Works, are recent, the firm were compelled by extension of business to acquire about two years ago several acres of land in open fields situated a mile away from the parent works. On this land they have erected new foundry buildings and a pattern shop. The old foundry at the Nautilus Works in the town has been dismantled, and is now converted into a new erecting shop. The new foundry at Westland measures 300 ft. by 115 ft., divided into a light and a heavy bay, equipped with electric travellers, moulding machines and light railways. New buildings adjoining have been erected, also for ultimate use as machine and erecting shops, and would have been so equipped now, though at the present moment they are engaged on war orders. The location of the new works was largely determined by the fact that the Great Western main line runs alongside the land, which is linked up directly with sidings to the shops.

The unavoidable separation of the old and new shops is one which has been frequent in recent years. There is no serious objection to it. The problem is solely one of judicious rearrangements, and that largely of intercommunication and transit. Our present subject, however, only embraces the original machine, shops built in 1911, the new ones being, as stated, otherwise occupied just now.

The Nautilus shops are shown by the plans, Figs. 4 and 5, on page 122, and elevation, Fig. 6, on page 123. The many advantages that result from the opportunity of laying out a brand new factory can be appreciated after the study of these works. Every detail has been arranged with the object of producing the firm's engines in a very large range of dimensions. The valuable experiences which were gathered during the building up of an extensive business have been utilised here, leaving nothing to chance. Not only in the general lay-out of the shops themselves, but equally in their equipment is this evident. The two drawings (Figs. 4 and 6) are not made to the same scale, the scale of the sectional elevation (Fig. 6) being twice that of the plan. The widths of the wide and narrow bays can be noted by the locations of the rows of stanchions in the plan. These are shown in detail in Figs. 7 and 8. The wide bay comprises a floor only, the narrow bay includes a gallery, shown in plan in Fig. 5. The disposition of the machines in the gallery is given in Fig. 6. Access to the gallery is by a staircase situated midway in the building (Fig. 5). Truck lines are distributed about the floors with complete connections outside to the test and paint shops. Lines also serve the double row of lathes in the gallery. The ground floor area of this machine shop is 10,600 sq. ft., and the area of the gallery is 3,600 sq. ft. The heavy castings are stored in a yard adjacent to the shops, to the right of Fig. 4, which is covered with a gantry. Tracks from this yard communicate with the shops. A system of low trucks is in use having sides to enclose a number of small castings, and with covers to lay on the sides on which a single large casting can be placed.

The machines in this building are grouped so as to provide for an easy flow of the material through the shop. Commencing at the west end, to the left, there are the horizontal boring machines for engine beds, and passing down through the middle of the large bay we have the drilling department on the right, and the vertical boring mills for flywheels, &c., on the left. Further along, the shapers are grouped on the left, and on the right are a large planing machine and horizontal boring machine for handling multi-cylinder beds. Further on at the right-hand side are the crankshaft lathes, and on the left-hand side a very fine battery of hexagon turret lathes. On the ground floor under the gallery, commencing at the east end, there is a range of six centre lathes with all-geared heads, and at the west end there is the milling machine department and the grinding department.

The east end of the gallery (Fig. 5) is given up to capstan and turret lathes, and automatic lathes, all handling bar work or light castings. The west end of the gallery is the tool-making department, containing toolmakers' lathes, milling machines, &c. The arrangements of the screw machines in echelon in the gallery may be observed. It is commonly adopted because it is the only way to economise floor space when stock bars stand out several feet behind the headstock. The amount of angle may range from 12 deg. to 16 deg. between the line of shafting and the axes of the machines. This slight angling does not affect the belt drives.

The system of driving adopted is that of motors serving lengths of line shaft, which shafts run in Cooper roller bearings. The machine bay is driven by four electric motors all placed in the corners of the building, two on the ground floor (Fig. 4) and two in the gallery (Fig. 5). The power plant is shown by Figs. 9 to 11, page 123. The gas is generated by the firm, and is supplied to their own engines of 100 horse-power. These drive dynamos through belts in the main power house. In the other house the dynamo is direct-coupled to a six-cylinder 100-horse-power engine.

The dispositions of the line shafts are seen in the sectional elevation (Fig. 6). In the plans they are denoted by the dot-and-dash lines. All the heavy machine tools are located in the main bay, and are served with a travelling crane (Fig. 6). Its services are supplemented by those of jib cranes at various heavy machines. Line shafting extends down the outer wall of the shop to drive countershafts and machines along that side. It is kept close to the wall to leave room for the traveller. The machines on the other side of the bay are driven from a line shaft in the centre of the narrow bay, which also serves the countershafts that drive to the heavy tools on one side, and to the light machines in the narrow bay. The light machines on the gallery floor are driven from a line shaft and countershafts in the roof as seen in Fig. 6. Although belt-driving is adopted, the stepped cones are not used on any lathes, which have all-geared heads. Tools of high-speed steel only are employed.

Some observations suggested by the methods of these shops may be offered. It will be helpful if we compare the plans in Figs 4 and 5 with the photographs, Figs. 12 to 15, on Plate XIII. Fig. 12, Plate XIII., is a general view taken in the large bay on the ground floor. The narrow bay is to the right, with the gallery above. The staircase leading up to the gallery is seen half-way down the shop. Fig. 13 is a view of the same large bay, but taken from a position in the gallery. Fig. 14, Plate XIII., is a view of the narrow bay on the ground floor underneath

THE ARRANGEMENT OF MACHINE SHOPS; THE SHOPS OF MESSRS. PETTERS, LIMITED.

Fig.4.

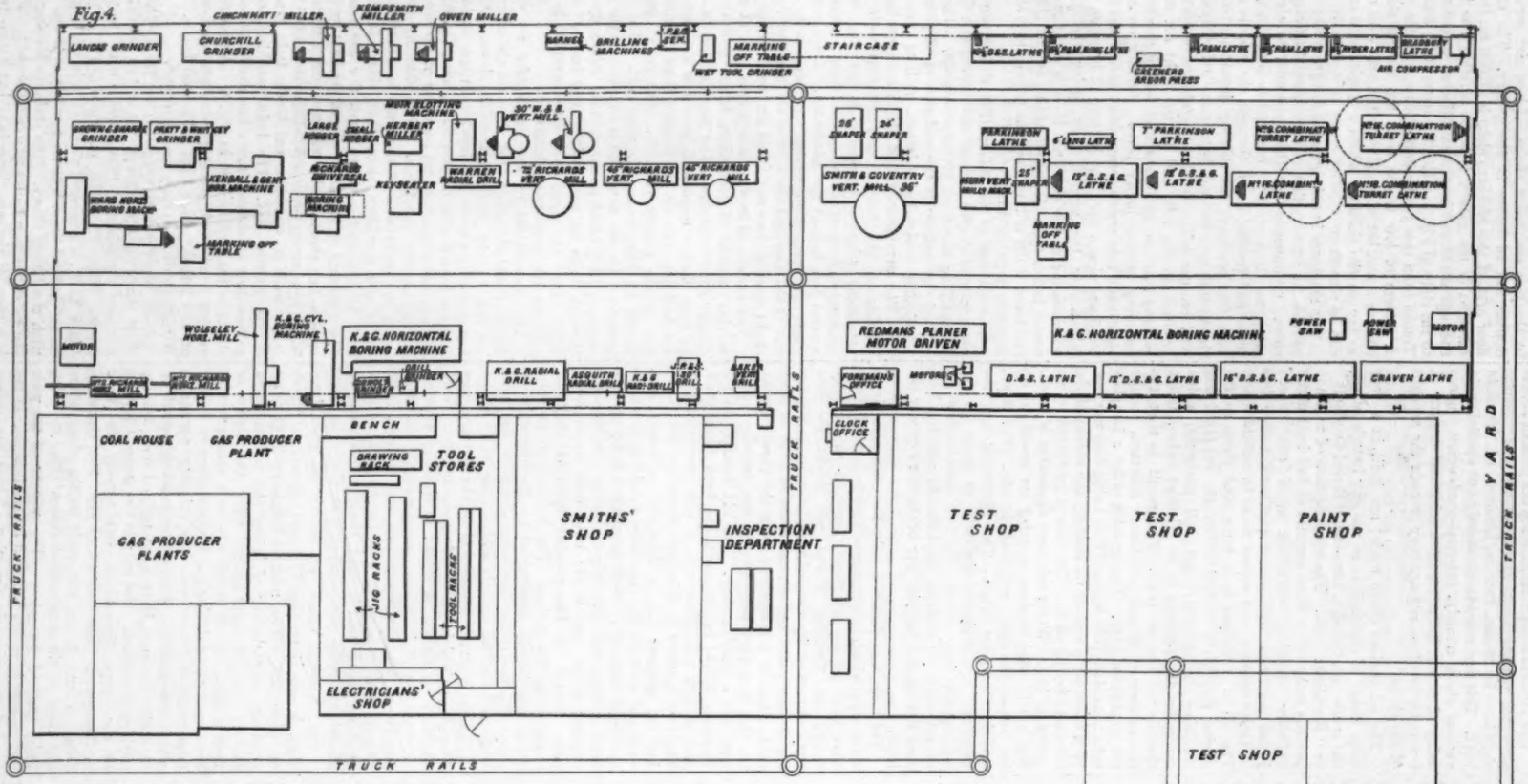
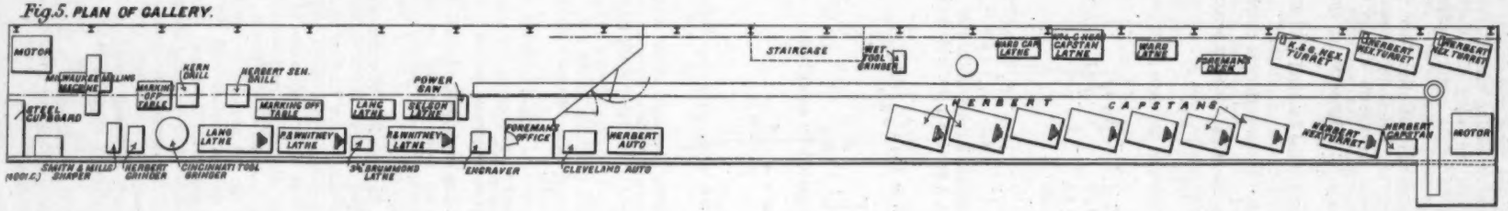


Fig.5. PLAN OF GALLERY.

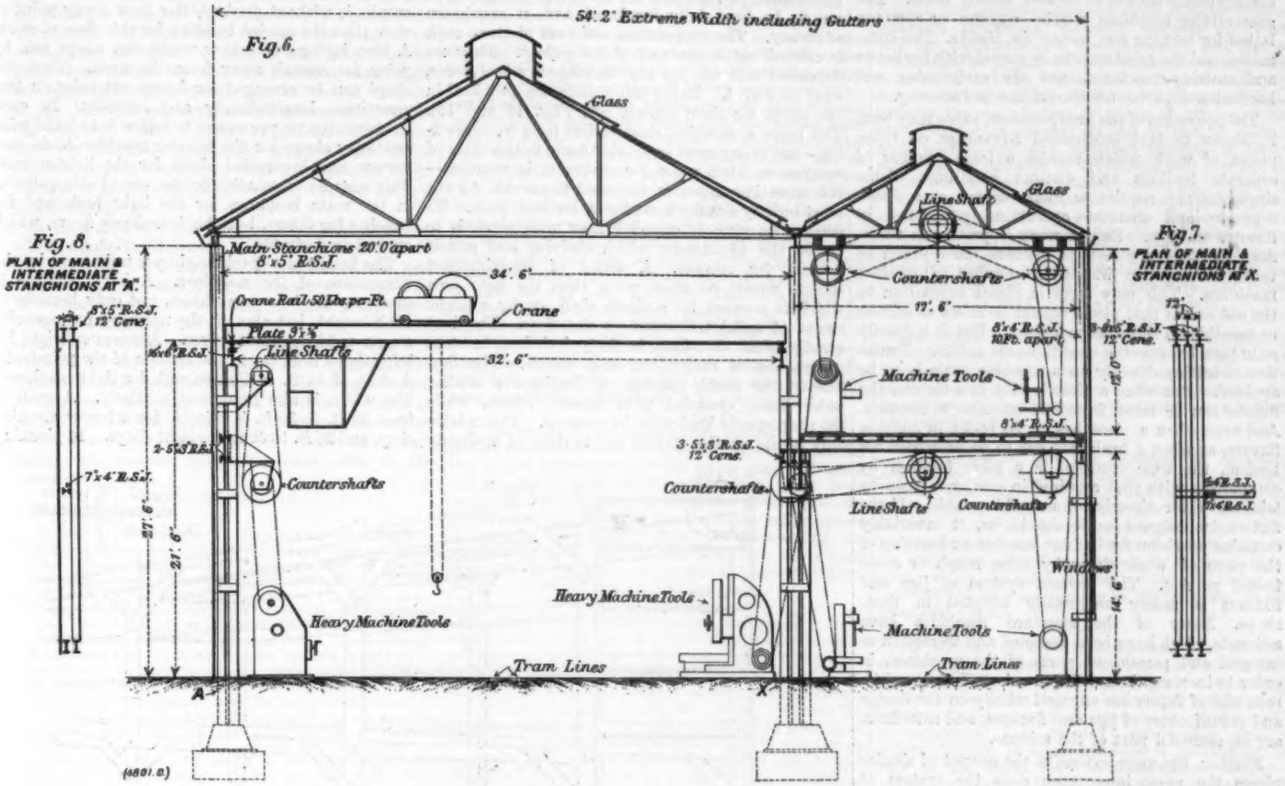


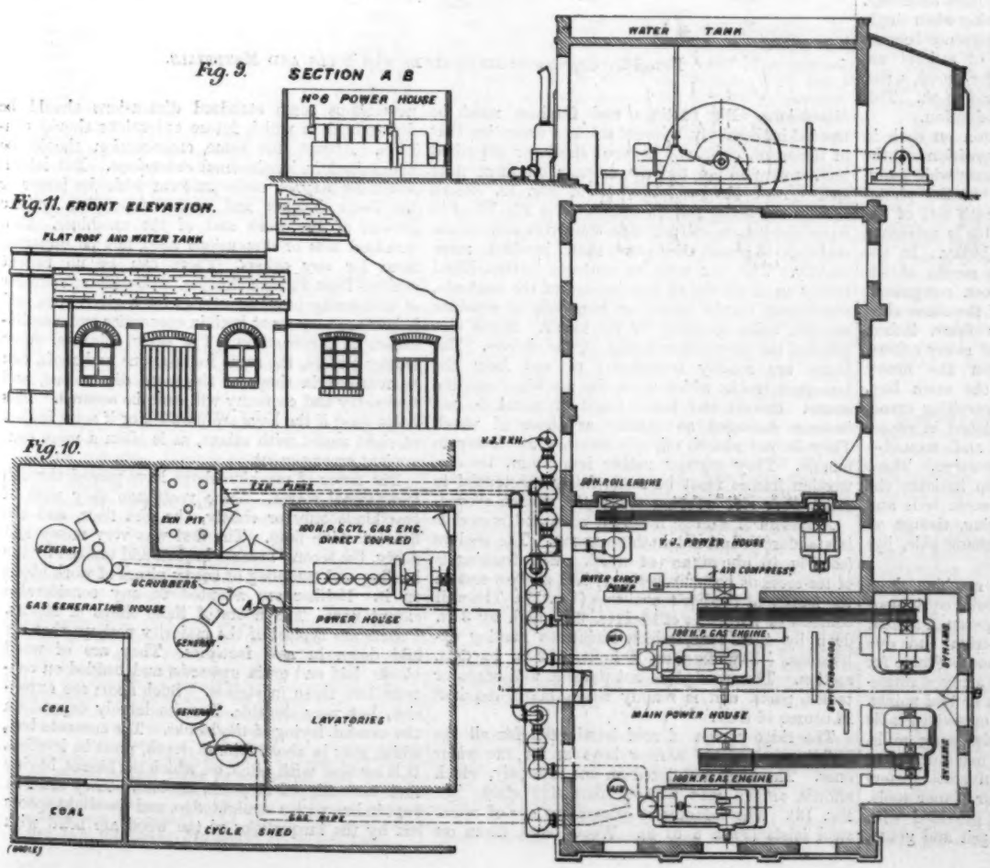
the gallery. Fig. 15 is a view in the gallery taken from the end where the capstan and turret lathes are located.

The scheme, it will be observed, which is adopted here is not that of the small group driving of machine tools, but of considerable lengths of line shafting. Only one machine is driven by its own motors—a Redman planer. The justification of long line-shaft driving here is that the work is all of a cut-and-dried character, that it does not fluctuate, in the sense of one group of machines being congested with work while another group adjacent is waiting for stuff. The manufacture is wholly standardised, and carried through in sets, and all the machine tools have been selected and arranged solely in order to secure this result, to the exclusion of all other contingencies such as would arise in shops that deal with general manufactures. Here, then, the advantage seems to lie with large motors, which are more efficient than small ones. The friction losses in the shafting are minimised, as stated, by the employment of roller bearings.

Again, the grouping of all machine tools of a kind together is frequently regarded as the ideal arrange-

THE ARRANGEMENT OF MACHINE SHOPS; THE SHOPS OF MESSRS. PETTERS, LIMITED.





ment. In the older shops it was hardly ever done; in the new ones it is usual. There is yet another method which combines both systems, and which in some cases is more advantageous, but it presupposes a highly specialised manufacture. In this system machines are disposed with less regard to character grouping, but more to the sequence of the operations performed on the manufactured products. This method of arrangement is well exemplified in the shops now being described. The sole object in this arrangement is to avoid backward movements of the work into different departments. The result is that lathes, drills, milling machines, boring machines, and again drills and grinders, &c., may be grouped in succession, so that an article may travel onward from one to the other from its commencement to its completion. This is feasible in many shops now, and especially when machining is done through fixtures and jigs that are often designed strictly for a machine of one particular size. The only objection to this grouping is the possibility of new methods of tooling being adopted at some future time. But this is not so likely to occur when all work is jigged as when it is only lined out.

There are limitations naturally to such a grouping. It can only mainly concern pieces which must pass through several machines. There would obviously be no advantage in sandwiching gear-cutting machines, or automatics,

or grinders between machines of other kinds, because these form self-contained groups by themselves. But these also have satellite machines, which in the group arrangements should be located among them. The gear-cutting machines require capstan or common lathes for turning and boring the blanks. The automatics and the grinders may be served with hacksaws and centring machines, and the carbonising and hardening departments should not be far away.

The operation of the group system, as we may term it, shows to best economical advantage on those pieces of work which require a large number of separate toolings and distinct handlings. Some single articles require as many as ten or a dozen separate and distinct operations performed in fixtures and jigs. Engine work is prolific in these. And the tendency now is towards the division of tasks between an increasing number of distinct machines. This may seem in direct opposition to the old axiom that pieces should be re-set as seldom as possible on different machines. But it is hardly so in fact, because the conditions are unlike. Tentative re-setting directly on a machine table is to be avoided. But when a piece is held in a fixture, the fixture can be taken from one machine to another. And even when a piece has to be re-set in another fixture, as when a fresh face has to be presented for tooling, the time occupied is a mere fraction by comparison with that required in setting a piece by trial and error directly on a machine table. If the fixture is designed as it should be, it invariably contains provision for instant location and setting of the piece of work either by some rough or some tooled portion. The modern system of jigs and fixtures is nearly universally adopted in these shops. Many of the standard machines have adjuncts which have been designed and worked in as integral and permanent parts of the machines, in order to increase their utilities. A staff of draughtsmen and of fitters are engaged wholly on the design and manufacture of jigs and fixtures, and rate-fixers are an essential part of the scheme.

Further, the more extensive the output of similar pieces the more importance does the system of grouping machines by sequence of operations assume. It becomes a problem of high economy. Economies which are well worth making when single machines of a kind are arranged in sequence become multiplied when several machines of a kind are arranged in a row as units in the larger group, a row of drills, a row of milling machines, and so on. This is the latest development in rapid production.

The names of the machines written on each in Figs. 4 and 5 will enable the disposition of the various kinds to be grasped. The very wide gangways in the shops will be noticed in the photographs, leaving abundant room on each side of the tracks for the handling of work. This is necessary because many of the castings are bulky. In the selection of the machine tools the merits of the productions of many firms have been recognised. It is interesting to note machines of the same class from many English and American firms, lathes, grinders, boring machines, drills, and many others. And although in their distribution the heavy machines are contained wholly in the main bay, where they can be served by the travelling crane, yet a few light machines are sandwiched in spaces that would otherwise be vacant and wasted—satellite machines in the operation grouping. Three marking-off tables in the main shop indicate the massive character of much of the work, beds and cylinders that are too large for jigging, though all the smaller details are strictly interchangeable, jigs and fixtures being freely used.

A highly important aspect of the machine shop, beyond its general lay-out, is the special equipment that is required for each machine or group of similar machines. This involves the provision and due maintenance of the tools and appliances suitable for each. Thus the lathes call for a large array of single-edged cutting tools, either solid tools or tool points. The milling machines require sets of cutters suitable to each type, the single cutters, the gang mills, the form cutters. The gear-cutting machines must be provided with sets of standard involute cutters for spurs and bevels, or with hobs or planer tools. The grinding machines have to be provided with mounted wheels in a large range of grit and grade, and with tools for retrueing them. And thus every different group of machine tools requires its own equipment of small tools and appliances, always maintained in readiness for service if the machines are to be kept fully employed and at maximum efficiency. The preparation and care of these tools is carried out at one end of the gallery. They are deposited with the jigs and drawings in a tool stores, seen in Fig. 4. Racks and stands are provided in the shops for their deposit (see Figs. 14 and 15). The more a machine shop suffers from overcrowding—and many must inevitably come to this state of congestion when room for extension is wanting—the more imperative is the need to provide for the most orderly arrangement for stores and tools. To occupy an already crowded floor with work is to ignore the advantages which shelving and stands possess for storage. A series of superimposed shelves covers no more room than the floor area which is covered by a single shelf, or by a single strata of articles dumped on the floor. The best arrangement, therefore, is that of shelves in store rooms, and of shelves on shop stands. The first receive the rough castings or forgings, a similar series being occupied with finished stores, while the shop stands hold work in progress. This relates only to the smaller articles and to those of moderate dimensions. Big castings and forgings must be treated individually, without storage, excepting that in the open, or in the covered sheds, or deposited temporarily in an orderly manner on open floor spaces near the machines, as in Fig. 13. Small articles are better put on stands, as in Fig. 15, or in boxes carried on shelves, than thrown loosely on the shelves, because they are then handled more rapidly. The box with its contents is then lifted bodily on or off the shelves instead of the contents, numbering maybe scores or hundreds of separate articles, being removed by the hands. Boxes also prevent the pieces from falling-off the shelves. The boxes are readily transferred to and from the transport trucks which serve the machines and the stores. Stands and boxes made of metal do not become damaged so readily as those of wood. They do not absorb oil, nor are they so clumsy to handle. They occupy rather less room, because wooden frames must be made fairly substantial to resist wear and warping under the weight carried.

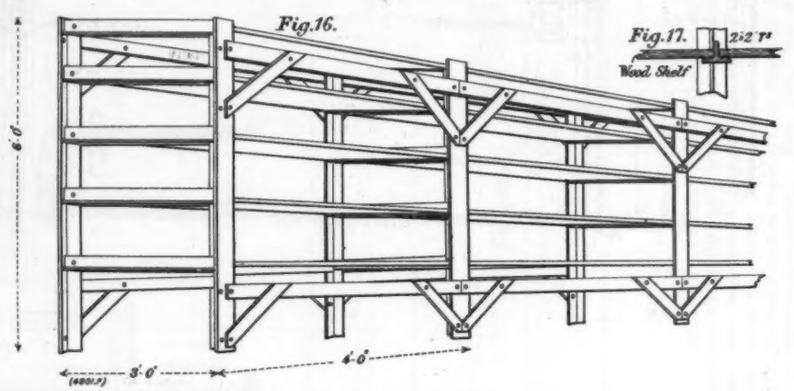


Fig. 16. Standardised Shelves for Tools and Materials.

A system of storage racks for tools and materials is standardised through these works. The shelves (see Fig. 16, above) are of wood. The framing is of tee-sections bolted together. The shelves rest on the flanges of the horizontal tees (Fig. 17). The unit consists of five tiers of shelves, 6 ft. high by 3 ft. deep by 4 ft. long, which facilitates making extensions. The framing is light, a 2-in. by 2-in. section. The wood does not damage tool edges or tooled parts, and is readily renewable if required in course of time.

The ridge design of roof is adopted for all the buildings, over the narrow bays as for the wider ones. The roofs are glazed on one side only, which affords ample light without excessive glare, (see Fig. 13). The columns or stanchions are of rolled steel joists (Figs. 6 to 8). Wood block floors on concrete are used. The roof coverings and walls are of corrugated iron.

With reference to these details we may remark first that the one floor system, supposing area to be ample, is without doubt better from every point of view than the storied building for this class of work. A firm laying out a new works can adopt this by going far enough away from the town. Then the shops can be arranged for future extension in two directions, longitudinally and laterally. In such a scheme the proper course to follow is to build wide and lofty shops for the heavier machine tools, and narrow and low-roofed shops for the lighter ones. This may be alternative to the use of side galleries in the main buildings for the light tools and for benches for fitters, but this introduces floors, which are not so desirable.

The height of a machine shop is influenced by the dimensions of the machines. A lofty building is necessary for heavy machines, not only because of their height, but also of the necessity for powerful cranes and longer belt drives. A common height for lofty shops is 30 ft., to the bottom of the principals. A shop of 15 ft. is high enough for light machines. The width is also influenced similarly. A span of from 30 ft. to 50 ft. is suitable for a heavy machine shop, and 25 ft. to 30 ft. for light shops. In planning new shops some standard dimensions should be determined to which future extensions should conform. Always the same cross-section should be maintained in longitudinal extensions. But lateral additions may be made uniform with the larger or the lesser heights and spans, depending on the growth of the work and of the machines. Two standard sets of dimensions need not be departed from for any others. There can be no benefit derived from further changes, while the advantages of uniformity in all scantlings for a given span and height are very great both in economies and simplification of construction. The same columns, crane gantry girders, the same foundations and roofs, can be retained in shops of the same dimensions, and symmetry and economy will each be secured. This holds good if the bays are parallel, or if some are set at right angles with others, as is often a more convenient arrangement.

The floors of machine shops have passed through transitional stages. Some years ago they were of two kinds only or chiefly, the dirt floor, and the floor of stone flags. The first was very messy and dusty, the second became broken and uneven by the hauling and tumbling of heavy pieces of work about on it. Neither are adopted to any considerable extent now. The floors of these shops of Messrs. Petters are typical of the majority perhaps that are laid down in new factories. They are of wood blocks, laid end grain upwards, and bedded on concrete like those in streets. Such floors are expensive, but very durable. Results largely depend on the careful laying of the blocks. The concrete bed, which may be about 6 in. in depth, must be levelled. It is covered with pitch, on which the blocks, having their ends dipped in pitch, are laid. They must be kept in line with a straightedge, and the slight spaces left by the inequalities of the wood are filled with

sand, or with sand and cement. This is to prevent dirt getting into and filling up the spaces later. The sand also closes the grain on the surface. The only objection to this floor is that it absorbs oil and moisture too readily. But otherwise it is practically permanent. If well laid it retains a good and level surface for all time. It affords also a sufficiently good foundation for the light lathes and light machines generally, which can be bolted directly to it. Heavier machines must be fastened down to the concrete. The heaviest of all must have deep concrete foundations specially prepared, and going down to depths which vary with the character of the machines, planers and slotters requiring the deepest foundations.

A rival to the wood block is the board floor, for which maple is employed. The advantage claimed for it is that it does not readily absorb oil, and that it can be kept clean from cuttings and dust. But it suffers from the attrition of the sharp-edged cuttings and from the workman's boots. It is not nearly so durable as the wood block floor, but it is suitable for the smaller shops where light machine tools are exclusively employed. The maple boards are grooved and tongued, and bedded on concrete. In addition they are nailed on beams or joists bedded with dovetailed edges in the concrete. These, again, are secured with ties below, also in the concrete.

LARGE WAR PROFITS IN GERMANY.—The Bockum Union for Mining and Cast Steel Manufacture, a concern with a share capital of 36,000,000 marks, has for the year ended June 30 doubled both its gross and its net profits and increased its dividend from 14 to 25 per cent. Having provided for war profit taxation, the available gross profits stood at 22,600,000 marks, against 11,900,000 marks for the previous year. The writings-off amounted to 5,250,000 marks, 750,000 marks more than during the previous year; a sum of 2,000,000 marks was reserved for the purpose of restoring the undertaking into "peace conditions," and the net profits amounted to 15,330,000 marks, against 7,400,000 marks in the previous year. The 25 per cent. dividend absorbs 9,000,000 marks; 1,000,000 marks are added to the national fund, 1,500,000 marks to the Baare Memorial fund, and 1,500,000 marks to the pension fund. The following table shows the growth of the net profits for the last few years:—

Years.	Marks.
1909–10	3,600,000
1910–11	4,400,000
1911–12	4,900,000
1912–13	6,400,000
1913–14	4,300,000
1914–15	7,400,000
1915–16	15,330,000

Although the Bockum Union may claim to hold a privileged position amongst the so-called mixed concerns under the present circumstances, on account of the important part the cast-steel production plays within its manufacture, its favourable balance-sheet is considered to augur well for other undertakings of the "mixed" class.

ELECTRIC VEHICLE COMMITTEE.—A meeting of the Electric Vehicle Committee was held in London on July 28, 1916, Mr. R. A. Chattock presiding. It was announced that the Royal Automobile Club had nominated as their representative upon the Committee Mr. W. Worby Beaumont. With reference to the correspondence that had taken place between the Board of Trade and the Electric Vehicle Committee on "Import Restrictions," it was decided, as a request had been received from one technical paper, that a copy of the correspondence should be sent to each technical journal. Consideration was again given to insurance policies for electric vehicles. Correspondence with the Car and General Insurance Corporation, Limited, was submitted, from which it appeared that the Corporation were willing to come into line with the suggestions previously made by the Committee, that their Standard Electric Vehicle Policy should be altered so as to include the risk on the battery while the vehicle is in transit by road, rail or ship. Subject to this alteration, the Committee considered that the Car and General Insurance Company's policy met every reasonable requirement, and they decided to give their approval to it. Arising out of correspondence that the secretary had had with the clerk to the Urban District Council at Rugby in the matter of providing charging facilities for electric vehicles, the secretary was directed to write and say that the Committee regretted the Council's decision not to provide such facilities at the present time. It should be noted that the British Thomson-Houston Company are prepared, when their own arrangements admit and at times convenient to themselves, to charge electric vehicles passing through Rugby. The secretary reported the action he had taken in connection with the report made by the Borough Engineer of Southwark to the Works Committee of the Council, and his action in this matter was approved. The date of the next meeting was fixed for Friday, September 29, at 2.45 p.m.

INDUSTRIAL NOTES.

A CHART recently prepared by the Republic Iron and Steel Company comparing steel prices and wages of common labour in the years 1899 to 1915, and in the first four months of 1916, is reproduced in the *Iron Age*. To this chart is annexed a second one, showing the purchasing power of a 10-dollar bill in the years 1890 to 1915 inclusive. This purchasing power curve is significant in that it shows an almost uninterrupted decline in the period 1899 to 1915 covered by the prices and wages chart. In the period from 1899 to April, 1916, the wages of common labour were reduced only twice—in January, 1904, and in April, 1909. The first reduction lasted until May, 1905, or nearly 18 months, whilst the second was only of 60 days' duration. In April, 1909, the independent steel companies reduced wages 10 per cent., but this 10 per cent. was restored within 60 days. The striking feature of the wages line of the chart is that it shows a strong upward sweep from a level of 1.25 dols. in 1899 to 2.42 dols. in 1916. Thus the wages of common labour have almost doubled; in the meantime the purchasing power of a dollar has declined from about 104 to 70, or about one-third. The steel prices cover Bessemer steel billets, tank plates, soft-steel bars and beams, and the curves show that they have varied most extensively from year to year.

A conference of the South Wales Miners' Federation met at Cardiff last Saturday, when a motion to rescind the former resolution (referred to on page 100 *ante*), and to continue at work, was carried by a large majority. But without waiting for Saturday's conference, the men in many South Wales mines agreed to work all the present week, notwithstanding the previous decision. On Monday last there was a good proportion of the miners at the pits, the general average attendance being as high as 80 per cent.

Mr. Evan Davies, miners' leader, is reported to have stated a few days ago at Ebbw Vale that there is a pro-German element at work in the South Wales coalfield, and that every miners' agent knows it. "When the men are asked to make a sacrifice, these extreme pro-German people," added Mr. Davies, "attend the lodges and influence the decisions and deliberations of the men, upsetting all arrangements. If the miners of South Wales are going to follow this pro-German element, I am prepared to resign. I am a Britisher to the backbone and am out to do all I can to help to win this war."

Mr. Asquith received last week a deputation from the Triple Industrial Alliance on the question of the employment problems after the war. The deputation was introduced by Mr. J. H. Thomas, M.P., and Mr. Asquith was addressed by Mr. R. Smillie, president of the Miners' Federation; Mr. H. Gosling, president of the Transport Workers' Federation; and Mr. Bellamy, president of the National Union of Railwaymen.

In his reply, Mr. Asquith pointed out that the problems referred to were of the most serious and complicated kind. The raising of the gigantic British military force had meant an enormous subtraction from the industrial life of the nation. The three great branches of industry represented had contributed nobly to the interests of the nation, and it would show a want of gratitude and of justice on the part of the State if the latter did not endeavour by every practical available means to ensure when the war came to an end that the men who had shown such a splendid example of patriotic service be secured so far as was possible against any form of vital suffering. On the other hand, justice had to be done to those who filled the gaps created by the large armies sent into the field. The problems gathered themselves round two facts: re-instatement of those who had gone and displacement or replacement of those who for the time being stood in their place. It was quite right that while the war was still raging, such time and attention as could be spared should be used in forecasting the provision that had to be made for the resumption of our normal activities as a peace-pursuing and as an industrial community. In regard to the departure from trade-union practices, Mr. Asquith said that the appeals in this direction had been accompanied by pledges of a distinct, explicit and emphatic character, and he assured the deputation that the Government had no intention of departing from them in the least degree. Nothing but the assent of all the parties concerned would vary them or dispense with their complete fulfilment.

The Board of Trade direct special attention to the National Insurance (Part II.) (Munition Workers) Act 1916, and point out that this Act extends temporarily the scheme of compulsory insurance against unemployment embodied in Part II. of the National Insurance Act, 1911, so as to include all workpeople engaged in the manufacture of ammunition, fireworks, explosives, chemicals (including oils, lubricants, soap, candles, paints, colours, and varnish), metals and the manufacture or repair of metal goods, rubber and goods made therefrom, leather and leather goods, bricks, cement, and artificial stone and other artificial building materials, sawmilling, including machine woodwork, and the manufacture of wooden cases; and also all workpeople employed on munition work in any trade (whether or not the whole trade is insured under this Act or the original Act of 1911). "Munition work" includes the manufacture or repair of articles of any kind intended or adapted for use in war, or parts of such articles, and any materials specified in Orders made by the Minister of Munitions, and required for or for use in such manufacture or repair. Under the Act every employer is required to obtain unemployment books from all the workpeople employed by him who are engaged on munition work or in one of the trades above-mentioned, and to affix unemployment insurance stamps to such books. The new Act will come into force on Monday, September 4, and contributions will be payable on or after that date.

The Right Hon. Arthur Henderson, M.P., Minister for Education, has resigned this office owing to the large amount of work he has to carry out for the Government in the matter of labour. It is understood that he will nevertheless remain in the Cabinet as a Minister without portfolio.

Judge O'Connor, who was appointed by Sir George Askwith to arbitrate in the matter of the wages dispute between the South Wales and Monmouthshire iron and steel workers and their employers, has issued his award. At the last quarterly audit the prices of steel rails and tin bars showed an increase of 24.5 per cent.; the employers offered an increase in wages of 10 per cent., which the men refused. Judge O'Connor has awarded the men an increase of 10½ per cent., to date from July 1 last.

The Ministry of Munitions announce that the Committee appointed under the chairmanship of the Right Hon. Arthur Henderson, M.P., to report on the arrangements to be made for the release of workmen for holidays in relays without interruption of the output of munitions, has reported unanimously that no general system of relay holidays is practicable. In view of the urgent need to maintain the supply of munitions it is still impossible yet to contemplate the national or local holidays which the representatives of Workmen's Associations agreed to postpone in response to Sir Douglas Haig's message. The Minister, however, recognises that it is necessary to arrange for some period of rest in order both to carry out repairs to plant and machinery and to avoid the physical and mental exhaustion resulting from fatigue, and the consequent falling off in production.

The Minister therefore proposes to adopt the unanimous recommendation of the Committee that any munition works which have not been stopped for rest or holidays since Easter shall be closed for a period of four consecutive days in September, except in the case of filling factories and of certain other classes of work, of which early notification will be made, where military exigencies do not permit of closing and where a system of rest periods by relays will be arranged. The period selected by the Minister for the rest period (subject to unforeseen military exigencies) is Thursday, September 28, to Sunday, October 1, inclusive. It is to be understood that what is proposed is strictly a rest period for munition workers, and not a national holiday in lieu of the postponed bank holidays.

SULPHITE SPIRIT.—The Swedish Ethyl Company has entered upon a contract with the German State for the construction in Germany of 14 works for the manufacture of sulphite spirit according to their process. The Swedish firm is to erect the works, but they will be run by the State.

OPENINGS FOR BRITISH ARTICLES IN ITALIAN MARKETS.—The British Chamber of Commerce for Italy, Genoa, has recently issued two lists, Nos. 26 and 27, giving particulars of Italian firms who are seeking British connections. Information is also given in regard to the class of trade in each instance stated.

UNIVERSAL DIRECTORY OF RAILWAY OFFICIALS.—We have received a copy of this directory for 1916, the twenty-second year of publication. It is compiled under the direction of Mr. S. R. Blundstone, editor of the *Railway Engineer*, and is issued by the Directory Publishing Company, Limited, 15, Farringdon-avenue, E.C., at the subscription price of 7s. 6d.; price after publication, 10s. It opens with an index to names of British railways, tramways and railway institutions, and then gives details of the railways in the United Kingdom, Europe, the British Colonies, North and South America. It ends with a personal index of officials with reference to the railways they belong to. The information includes the length of track, the gauge, number of locomotives, carriages and wagons.

THE REYNOLDS AUTOMATIC SCREW-DRIVING MACHINE.

CONSTRUCTED BY THE REYNOLDS PATTERN AND MACHINE COMPANY, MOLINE, ILLINOIS, U.S.A.

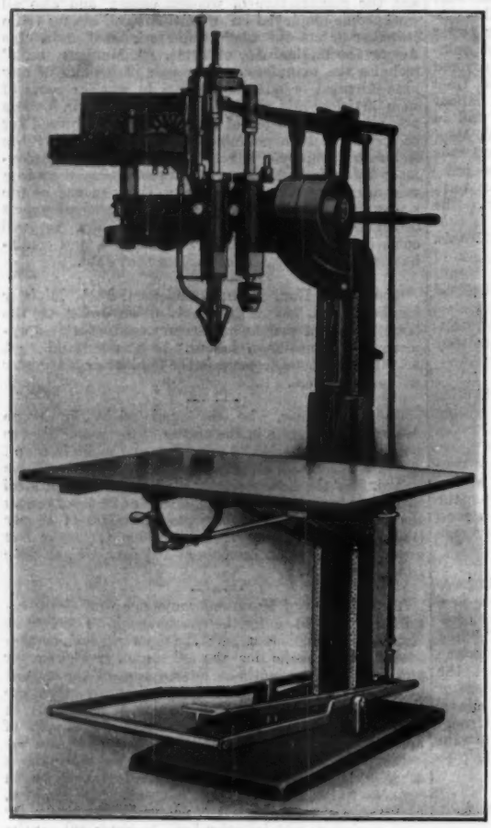


Fig. 1.

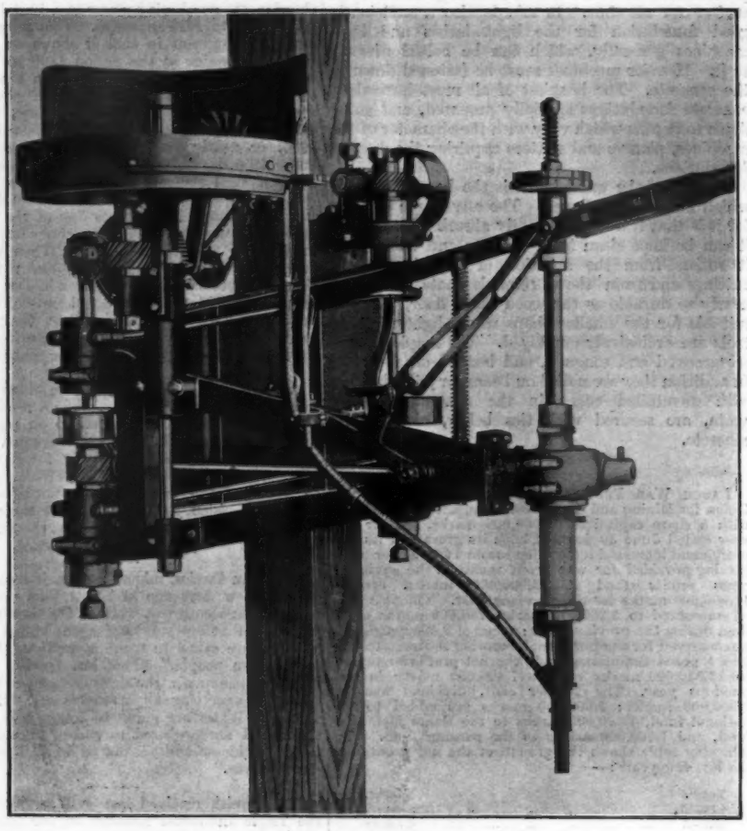


Fig. 2.

We illustrate in the views, Figs. 1 and 2 on the present page, a screw-driving machine for wood or machine screws constructed by the Reynolds Pattern and Machine Company, Moline, Illinois, U.S.A., whose agents in this country are the Universal Machinery Corporation, Limited, 326, Old-street, Shoreditch, London, E.C. The machine is connected to the overhead transmission by a belt which runs on fast and loose pulleys, the former driving the screwing spindle through an adjustable friction clutch. The screws are dumped into the hopper or magazine on the left-hand side of the machine, where they are automatically arranged and from which they are automatically taken one at a time. The work is placed on the table and the pressure of a foot-lever helps to drive the screw home. In many cases, screws can be set without previously boring for them where it is difficult to do so. After being taken automatically from the magazine, the screw is held by a pair of jaws until the driving spindle descends and engages the slot in the head of the screw and forces it down into the work; the jaws are controlled by springs which permit them to open. As stated above, the spindle is driven by an adjustable friction device which makes it possible to set screws as tight as desired, and allows the spindle to stop when the screw is home, thus avoiding marring the work or the heads of the screws. The driving friction can be relieved at any desired point by a device which applies a brake to the spindle, arresting its advancing and rotary motion and allowing screws to be set to project to any desired height. The table can be set to any required height by means of a hand-crank. It is also raised by a cam on the foot-lever as each screw is driven, this being a valuable feature where small metal articles, such as hinges, are being secured to wooden work. The spindle is intended to run at a speed of from 600 to 1,000 r.p.m.; the screw is thus driven in a fraction of a second, and the output of the machine is only limited by the ability of the operator in adjusting his work. The operation of the machine by means of a foot-lever leaves both hands of the operator free. The table adjusts to 30 in. below the end of the chuck; the depth of the throat is 24 in. The power required is about 3 h.p. for wood screws and 1 h.p. for machine screws. The machine illustrated in the view, Fig. 1, is also provided with a boring attachment, operated also by a foot-lever; this can be used independently of the screwing device.

In Fig. 2 we illustrate a radial type of screwing machine designed for work too heavy or too bulky to be handled under a machine with a fixed spindle. The working parts are mounted on a jointed swinging arm made to be fastened to a post in the factory. In this, the action of the magazine can be cut off and the screws fed by hand, which is desirable in some instances, as in piano work, where screws of different lengths are used. The machine is also suitable for screwing up packing-cases and crates. In this type of machine, as will be seen, the screwing spindle is lowered and raised by means of a hand lever.

THE LYMN-RAMBUSH MECHANICAL GAS-PRODUCER.

The continuous rise in the price of fuel and labour was, even before the outbreak of war, a question of considerable importance in industry in general and to the metallurgical industry in particular, and is far more so now after two years of war. Many engineers feel that these circumstances will do much to bring about a great extension in the use of gaseous fuels. Furnace firing and gas heating carried out by means of a battery of gas producers as a centralised source of heat always mean much saving of labour, and this can be still further reduced beyond what has hitherto been customary by the provision of suitable mechanical arrangements, designed to permit of the cheapest or waste fuels being converted into good producer gas without additional labour for dealing with the high percentages of ashes which results from the use of such fuels.

On the opposite page we give illustrations of a producer of this type which is being introduced under the name of the Lymn-Rambush gas producer, by the Lymn Chemical Engineering Company, Limited, of 33, Tothill-street, S.W.

For attaining the most profitable and constant gas results when using gas producers it is essential that the fuel bed be maintained in a good gasifying condition over its whole sectional area. In a properly operated producer the fuel rests upon a complete layer of ashes at the bottom having a constant depth and grade over the whole area. It is important that this layer be never allowed to clog or set solidly together, nor should temperatures become high enough for the ashes to fuse, and cause clinker, a failing which it is very difficult to avoid with many fuels in an ordinary hot gas producer.

In the Lymn-Rambush producer accordingly the whole of the ash zone is kept in a state of very slow but constant motion, which indeed is not confined to this zone, but extends also into the lower layers of the fuel zone above. This motion takes place in both a horizontal as well as a vertical direction, whilst at the same time there is a slow but regular removal of ashes from all parts of the base of the producer proper.

In producers of the mechanical type previously built there has, in general, been only a single shovel, which removes the ashes at one part only, and this, it is held, causes an excessive local displacement of material from that side of the producer on which the shovel in question is fixed. The fact that the ash-bowl revolves does not eliminate this difficulty, because of its very slow speed of, say, one revolution in one or two hours. The arrangement criticised tends therefore to make the fuel bed more open immediately behind the ash-shovel than over the rest of the sectional area, which involves a serious risk of uneven gasification. The Lymn Chemical Engineering Company claim, moreover, that a further serious drawback is to be found in many existing producers, viz., that the apertures through which the air blast enters the lower zone of the producer are liable to become obstructed by ashes, owing to the pressure of the ashes against them. This results in considerable resistance to the passage of the air blast and consequently to a reduction in the rate of gasification.

A photograph of the Lymn-Rambush producer,

THE LYMN-RAMBUSH GAS-PRODUCER.

CONSTRUCTED BY THE LYMN CHEMICAL ENGINEERING COMPANY, LIMITED, ENGINEERS, LONDON.

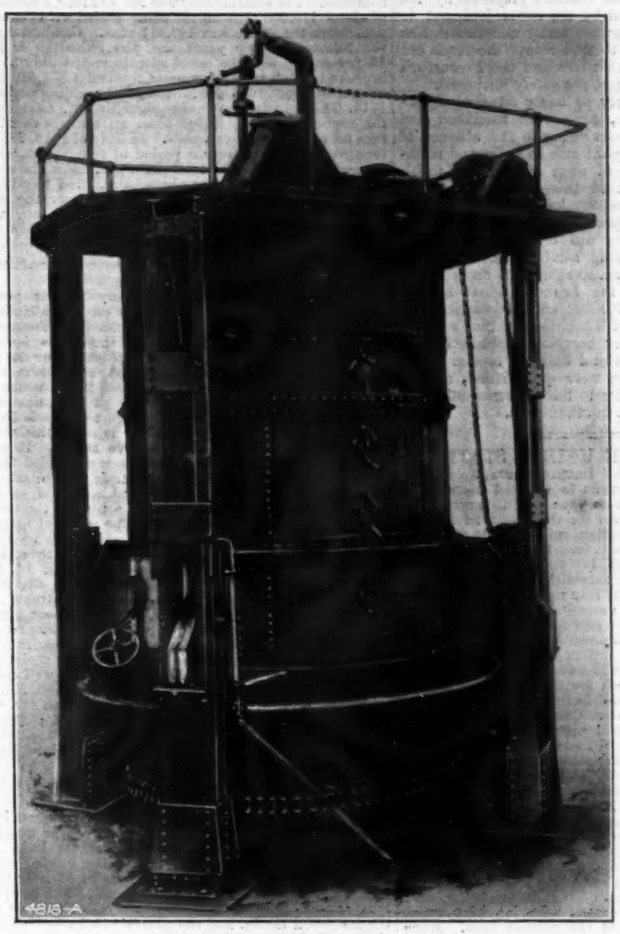
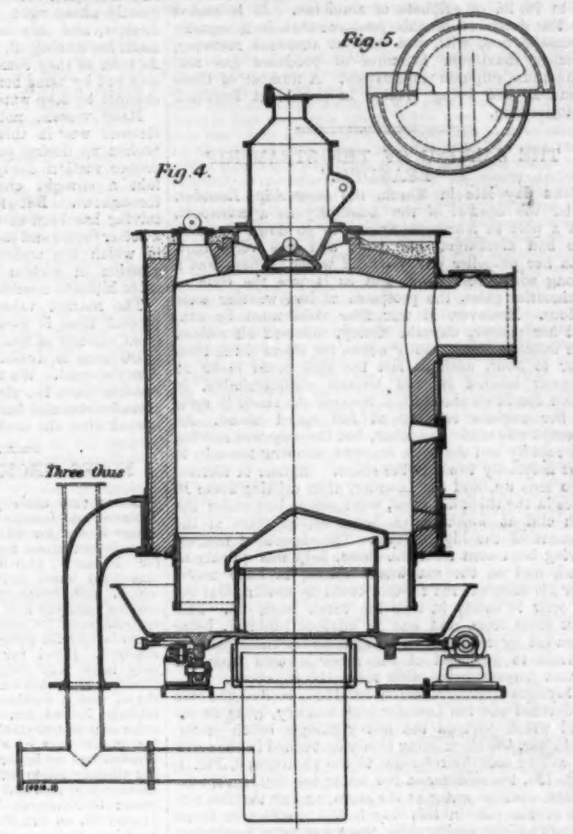


FIG. I.



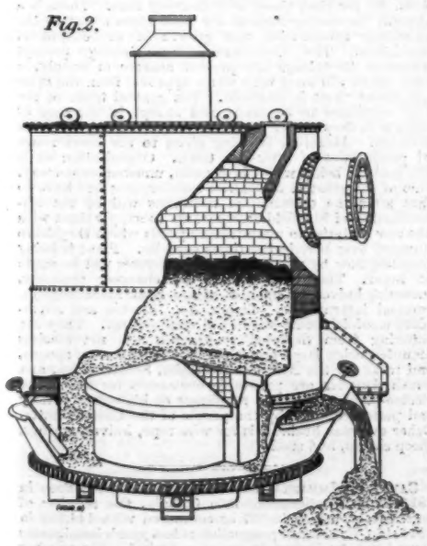
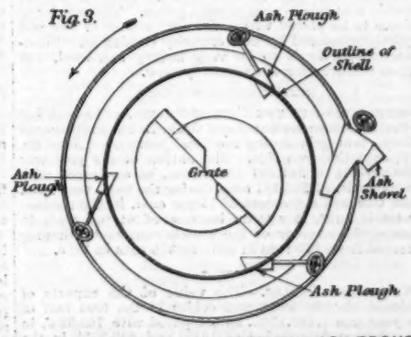


Fig.2.



SECTIONAL PLAN OF GRATE AND ASH TROUGH.

which, although British in origin, was first built in America, is shown in Fig. 1, but its main features are perhaps better shown in the perspective drawing reproduced in Fig. 2. A sectional plan of the revolving grate with the ash-removing mechanism is reproduced in Fig. 3. Fig. 4 is a vertical cross section. As will be evident from the figures, the producer is of the water-lute type, and the usual method of revolving the basin or bowl containing the ashes and water has been adopted. The ash-bowl, which carries the grate, is suitably supported and consists of an annular cast-iron turn-table, to the upper side of which is bolted the cast-iron side wall of the bowl, which has the shape of an inverted truncated cone. On its outer edge the turn-table is provided with a toothed ring which works in conjunction with a steel worm suitably driven by means of a ratchet wheel and an eccentric, thus bringing about a slow revolution of the ash-bowl and grate.

As indicated in Figs. 3 and 5, or perhaps even better in the perspective view, Fig. 2, the producer grate or air distributor has the shape of two vertical half cylinders laterally displaced along their dividing surfaces. The top of each half cylinder has much the shape of a screw propeller blade (see Figs. 2 or 4), so that during each half revolution a vertical propeller-like movement is imparted to the ash and fuel in addition to the balanced eccentric movement caused by the two laterally displaced half cylinders. This combination provides the desired gradual but regular horizontal and vertical movement of the charge in the most simple manner. It will, moreover, be obvious that as the grate is made of the most simple shapes, without necessitating left and right patterns, the manufacture is a perfectly straightforward proposition.

The slots in the grate, through which the air blast passes into the gas producer proper, are placed in such a position that they can never become obstructed with ashes, as the air passes direct into the two wedge-shaped openings formed by the displacement of the half cylinders. These openings in revolving move away from the ashes, which consequently remain extremely loose.

In order to secure uniform removal of the ashes from the whole circumference of the producer proper, simple ash-ploughs or scrapers are fixed upon the bottom of the producer, as shown in Figs. 2 and 3. These have the effect of loosening or ploughing up that part of the ashes immediately under the producer proper, and of displacing them into the revolving ash-bowl, which then carries them round until they reach the ash-shovel which discharges them into the ash-truck direct or on to the ground. It will be seen that although only one ash-discharge shovel is provided, the series of ash-ploughs remove the ashes continually and regularly from the bottom of the charge inside the producer, thereby maintaining the fuel bed always in a constant condition for good gasification.

Although at first sight it might seem as if the double-stage ash removal were a complication, it must be borne in mind that neither stage involves the use of any mechanical gear whatsoever, and that the ash ploughs themselves, being attached to the base of the producer, operate quite automatically and without the slightest manual attention. Moreover, their depth can be so regulated as to deal comfortably with any quantities and qualities of ash, without any of the difficulties attributable to a single-stage ash discharge. The final result of this arrangement is that all grades of coal, even the waste dump heaps of collieries, containing up to 40 or 50 per cent. ash can be satisfactorily used, producing a good gas.

The actual result of several months' night and day

operation with a colliery waste of a coking nature containing 35 to 40 per cent. ash, was a production per ton of fuel gasified of 110,000 cub. ft. of good gas, and when worked under ammonia recovery conditions 60 to 70 lb. of sulphate of ammonia. It is stated by the designers of this producer that it is equally successful both with and without ammonia recovery, yielding maximum amounts of producer gas and ammonium sulphate respectively. A number of these producers are being erected in important munition factories here.

THE SALVING OF THE STEAMSHIP "LEANDER."

One day late in March, the steamship Leander, under the control of the Admiralty as a transport, left a port in Northern France to go down Channel. She had discharged her cargo and was very light, with her propeller partly out of water. There was a strong south-west wind, and as it was the time of equinoctial gales, the prospects of bad weather were serious. However, in war time risks must be run, and her master, Captain Ketley, followed his orders. The weather grew steadily worse, the storm rising from hour to hour, until at last the ship could make no progress against it, and became uncontrollable, in which condition she drifted towards the shore in spite of her engines running at full speed ahead. An attempt was made to anchor, but the ship was moving too rapidly and the cable snapped, allowing the ship to drift helplessly towards the shore. Signals of distress were sent up, and the Leander, after drifting some 10 miles in the thick darkness, went ashore just under the high cliff at Southbourne, being driven there at the moment of the highest tide. The signals of distress having been seen from the shore, help was quickly at hand, and as the sea was breaking in huge waves over his steamer, the captain could do nothing but get his crew to safety in case the vessel broke up. This took some time, and was an anxious problem, being attended by considerable danger, as darkness made it difficult to get hold of the ropes lowered from the almost perpendicular cliffs some 100 ft. above.

Daylight broke on March 29, 1916, to find the sea moderated and the Leander high and dry, lying on the sand which covered the heavy shingle beach underneath her, the stern being firmly embedded in the sand. As will be seen by reference to the photograph, Fig. 1, page 130, the steamer at low water was dry, except for a little shallow water at the stern, and as the rise and fall of the tide in this bay is the smallest in Great Britain at high spring tides, there was quite insufficient water to help her to get off.

Soundings having been taken, it was found that the sand lay almost flat for 440 ft. from the stern, the slope over that distance being very gradual. Nowhere within this distance was there deep enough water for the steamer to float, and the whole prospect of ever getting the boat into the sea again looked thoroughly hopeless.

After ineffective trials it became evident that the only possible way was to cut a temporary channel from deep water towards the steamer's bow, which meant some 700 ft. through the sand, so as to get a sufficient depth for flotation. Those in charge of the salvage were lucky in being able to engage the only British-owned suction dredger suitable to carry out such a difficult task, and on May 12, 1916, some 10 weeks after the stranding, the British Dredging Company's powerful suction dredger Precursor was seen lying in deep water off the Leander with her stern pointing to the shore. Gradually, yard by yard, working stern first, and (throwing overboard through her powerful pumps some 2,000 tons of sand per hour) the Precursor made her way towards the stranded vessel. After a couple of days of almost constant pumping, the dredger was within a short distance of the Leander's stern quarters (Fig. 2), having made a straight cut of 440 ft. from deep water. The channel was formed from the dropping of the dredger-head, 440 ft. away, about 40 ft. in width and 14 ft. in depth, to the Leander's stern, where at high water there was a sea-water depth of about 6 ft. with 3 ft. at the bow.

It then became necessary to cut a second channel near the first, and finally merge the two channels into one, so as to get greater width to manœuvre the dredger, and also to bring the steamer through when floated (Fig. 3). This accomplished, a wet dock some 14 ft. minimum depth had to be formed as far up the port and starboard sides as the heavy shingle would allow, with lots of breadth at the stern end, where the material was mostly sand. This was successfully carried out to within 68 ft. of the bow on the port side (Fig. 4), and 120 ft. on the starboard side, at which points the shingle met with was too heavy and solid to be removed by pumping, but fortunately the buoyancy created was sufficient to let the steamer move a little.

After slipping some 20 ft. down the beach, although still held by the heavy shingle just under the foremast, the first rough sea, which happened on June 29 during the afternoon tide, caused the Leander to roll, and, as was expected, this rolling crushed away the understructure quite suddenly. The boat then found herself quietly afloat right in the channel prepared by the dredger, and only detained by the ropes laid out to assist her coming off, which were partly underneath her. As soon as they could be cleared away, she made her way out by using her own engines and the Precursor's channel to deep water, where she safely anchored.

Many vessels, not nearly so badly situated as the steamer was in this case, have been sacrificed and broken up during past years owing to the absence of proper suction dredging plant able to make and maintain a straight channel of even depth and width throughout. But now that this novel method of salving has been so successfully tried we may look to a better future and shall expect to hear of other instances in which the underwriters will benefit by the progression in suction dredging salving plant enabling ships hitherto considered unsalvable to be floated.

The market value of the Leander afloat at the present time is some 120,000*l.*, and considering the great scarcity of tonnage it is satisfactory that another 5,000 tons is available for carrying supplies to our Army abroad. We understand that the repairs which resulted from the stranding were quite small, as the Leander resumed her service to the Government about a week after she docked at Southampton.

NOTES FROM THE UNITED STATES.

Philadelphia, July 26.

Continued activity prevails in the rail market for domestic and foreign requirements; among large recent orders is one for 80,000 tons for the Southern Pacific, over 100,000 tons for Canadian railroads 14,000 tons for France, 12,000 tons for South Africa and numerous lesser orders, all for next year's delivery, which, with contemplated necessities, will crowd railmaking capacity still farther into next year. European requirements for cars are assuming large proportions. Negotiations for some 15,000 cars for Russia have been renewed. Local car requirements are known to be very large, but very few orders will be placed now. Demand for munition material has again assumed larger shape, and a continued rush for shell material is confidently looked for. Russia has bought 28,000 steel axles and 56,000 steel wheels. Canada is in the market for 26,000 tons of structural material. An enormous demand has set in for steel pig, and domestic production has slightly fallen off. Agricultural implement makers are heavy buyers and capacity is oversold. The United States Government is seeking bids, to be submitted August 23, on 943,000 shells of all sizes. Nearly all of American steel capacity is sold up to the end of the year. Incoming business is largely for next year's delivery, though shapes can be delivered this year. Shipyards on the Delaware River have 79 ships under construction and 2 very large shipyards are being built; in all the shipyards in the United States 385 ships are being built. Tin-plate mills are overwhelmed with inquiries which they cannot take care of at the present time. Much of the business sought to be placed is for export. General trade conditions are all that could be desired, and very much business remains in pigeon-holes because of prices and impossible delivery. Crop reports are in the main favourable and all demands will be met for export probably somewhere near present prices. The volume of business to be placed within the next month or two will be partly measured by new capacity coming in. Blast-furnace capacity is to be very largely increased, but furnace construction is necessarily slow.

Shipbuilding in the United States.—Shipbuilding on the American seaboard and Great Lakes yards scored an important gain during the fiscal year ended June 30, 1916, says the *Iron Age*. The output of the year was 1,030 vessels, of 347,847 gross tons, as compared with 1,266 vessels, of 215,711 tons, during the fiscal year 1915. While this was a decrease of 19 per cent. in the number of vessels built, it was an increase of 61 per cent. in tonnage, the average of the vessels constructed having increased from 170 tons in 1915 to 338 tons in 1916.

Wires and Cables.—The value of the exports of insulated electric wires and cables in the first half of this year was 1,187,170*l.*, as compared with 759,384*l.* in the corresponding period of 1915, and 899,373*l.* in the corresponding period of 1914. This year's total was made up as follows: Insulated rubber (not being telegraph or telephone wires or cables), 253,793*l.*, as compared with 141,109*l.* in the first half of 1915; insulations other than rubber (not being telegraph and telephone wires or cables), 428,312*l.*, as compared with 205,642*l.*; telegraph and telephone wires and cables (not being submarine cables), 282,688*l.*, as compared with 227,254*l.*; and submarine telegraph and telephone cables, 222,477*l.*, as compared with 185,379*l.* Telegraph and telephone apparatus were exported in the first half of this year to the value of 132,221*l.*, as compared with 99,407*l.* in the first half of 1915. Electrical goods and apparatus (other than machinery and insulated wire) were exported altogether to the extent of 2,038,123*l.* to June 30 this year, as compared with 1,486,998*l.* in the first half of 1915, and of 1,704,229*l.* in the first half of 1914. The extent to which this branch of our exports has been developed will, perhaps, surprise some of our readers.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

Hull Coal Traffic.—There continues to be a pronounced reduction in the coal traffic to Hull from South Yorkshire collieries. The total for July was 297,437 tons, a reduction of about 170,000 tons on the same period of 12 months ago, when the figure was 467,917 tons. Compared with the tonnage of two years ago, the reduction is fully 50 per cent. For the seven months ended July 31 the imports to Hull from all sources totalled 1,914,489 tons, as against 2,843,863 tons for the corresponding period of 1915. The exports also denote a big falling off. Last month the exports reached 113,545 tons, an average of 22,709 tons for each of the five weeks. In July of 1915, 283,733 tons were exported over a period of four weeks, or an average of over 70,000 tons per week. For the seven months the quantity sent abroad amounted to 622,643 tons, as compared with 1,391,498 tons over the same period of last year. During July 25,098 tons were exported to London and other home ports, 64,586 tons to France, 20,924 tons to Italy, 8,651 tons to Sweden, 8,323 tons to Egypt, 7,726 tons to Holland, and smaller quantities to Norway and Denmark.

South Yorkshire Coal.—Satisfactory reports are to hand of the conduct of the miners on Bank Holiday. In the majority of cases only a small percentage of absenteeism is reported, though there are isolated instances were many of the men "played" for one day and even two days. There is an easy tone in the market, due to the ample supplies of all classes of fuel which are available. The local consumption of manufacturing coal is on a very large scale, but full tonnage is forthcoming, and in certain cases there is a surplus, which works are diverting to their reserve stocks. Exports are down all round, and this has been a decided factor in easing the home situation. Neutrals are not offering such fancy prices for South Yorkshire hards as previously, and this, coupled with yet a further tightening of the export restrictions, has had the effect of limiting the transactions. In the matter of shipments to Allied Powers, a scarcity of freights has prevented these from expanding. There has been heavy buying of gas-making coal for inland works, whilst it is distinctly noteworthy how the business outside contracts has increased during the past week. There has been a good deal of purchasing in the open market. Slacks remain easier at slightly decreased values, for collieries have an abundant tonnage on offer. For cokes there is a persistent demand, and current values are well maintained. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire best brights, 17*s.* 6*d.* to 18*s.* 6*d.*; Derbyshire house, 16*s.* to 17*s.*; best large nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; small nuts, 15*s.* to 16*s.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; smalls, 8*s.* to 9*s.* per ton.

Iron and Steel.—Sheffield consumers of common irons are still awaiting a clear definite ruling on the question of prices. At present Derbyshire makers have not advanced their commodities, and in any buying which has been done recently the old figures of 85*s.* for forge and 87*s.* 6*d.* for foundry have been paid. Nor have the local consumers of other brands been called upon to pay the increased tariffs, and the general opinion is held that there will be some difficulty in obtaining the higher figures through the lack of united action on the part of the makers. Hematites have not undergone any change. The prices are still 136*s.* to 140*s.* for West Coast and 128*s.* 3*d.* for East Coast with delivery here. There is a steadily increasing demand for both classes, due to the enormous acceleration and growth of the output of munitions. The Government are taking prompt measures to enlarge the present sources of supply, a step which will meet with warm approval from the large armament firms in Sheffield. The general trade of the city continues to be brisk, and except in the case of certain cutlery firms, there was no slackening on Bank Holiday. Attention is being given to the great range of possibilities of after-war trade. Organisation on a big scale is being made in a quiet, unostentatious way. One of the greatest difficulties the Germans will have to face after the cessation of hostilities will be the disinclination of Sheffield steel-makers to supply them with the raw material to manufacture goods which they have dumped over here in the times gone by. Plant is being installed now by which such manufactures will be made at home. These are chiefly the cheapest products, including knives, tin-openers, spikes, razor blade forgings, surgical instruments, scissors, &c. Electro and silver-plate establishments are in full employment. They are suffering from depleted staffs, but are nevertheless manufacturing large quantities of steel helmets, spoons, and forks for the Army. Australia, South Africa, and South America are profitable customers for silver and electro-plate, whilst big purchases of high-class cutlery and plate are made by the people of the United States. Other overseas business is for wire rope, knives, springs, sheep shears, and steel.

Canadian Immigration.—There was a great drop in 1915–16 in immigration into Canada, the number of new arrivals being 48,537 as compared with 144,789 in 1914–15. The largest proportion of last year's immigrants came from the United States, viz., 36,937. The number of British immigrants was 8,564; and of immigrants from other countries, 2,936. The result of last year's immigration was to strengthen rather materially the proportion of new American population. Miscellaneous immigration of last year included 27 Germans, 15 Austrians, 65 Jews, 179 Russians, 338 Italians, 180 French, 88 Chinese, 401 Japanese and 591 Scandinavians.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—No move has yet been made towards the revival of the pig-iron warrant market, and matters are just as they were a week ago, and, indeed, for many weeks now.

Scotch Steel Trade.—Gradually and steadily during the past few months has the producing power of the steel-works engaged on war contracts throughout Scotland been increased, in many instances by extension of plant; and the total abandonment of the customary July holiday has permitted an output of war material much in excess of the expectation of the most sanguine. Still, there are two deterrent factors which are greatly adding to the anxieties of producers—shortage of labour and the difficulty of procuring a sufficient supply of raw and semi-manufactured materials. With new orders constantly coming to hand this is a very real trouble, which not even the employment of large numbers of women is able to mitigate to any appreciable extent. Every effort is being made, however, to cope with the Government's demands for steel of all grades—which seem to be limitless—and to expedite delivery in the best manner possible. This pressure continues to crush out all ordinary mercantile business, and when the tale of what has been done in the West of Scotland alone comes to be known, there will be some surprising revelations as to the actual output. Export trade is now farther off than ever, the recent Order in Council having to a greater extent restricted this branch of business. Prices all round are well maintained—steel ship plates running from 14*l.* 15*s.* to 15*l.* or so; boiler plates are, roughly, 16*l.* f.o.b. Glasgow; and angles are 14*l.* 2*s.* 6*d.* per ton and up.

Malleable-Iron Trade.—Directly or indirectly the vast output of the local malleable-iron works is all being absorbed on Government account, and, even with the mills running unceasingly, night and day, makers have difficulty in supplying the many demands made upon them. As orders are constantly on the increase the pressure is correspondingly heavier. "Crown" bars for home delivery still run about 14*l.* 12*s.* 6*d.* per ton, less 5 per cent., while for export the price is off and on about 14*l.* 2*s.* 6*d.* per ton for ordinary grades, with the better-known brands one or two shillings over this level.

Scotch Pig-Iron Trade.—There is still a pressing demand for all classes of Scotch pig-iron, particularly for the hematite grades, almost the entire output of which is being consumed at the local steel works. Indeed, so much is being required in this direction that there is difficulty in obtaining supplies for shipment direct to our Allies, so that practically no licences for export are being granted. Ordinary grades of foundry iron are also particularly scarce. Prices are unchanged.

Munition Workers' Holidays.—Last evening, at a meeting of delegates of the shipbuilding and engineering trades in Glasgow and the West of Scotland, convened to consider the question of holidays in relays, a telegram from the Ministry of Munitions was submitted, in reply to one sent by the Clyde Local Labour Advisory Board. In the interests of health, the delegates deprecate the action of the Government, and have called upon the Trades Unions concerned to make arrangements for carrying out the system suggested at several previous meetings.

Scotch Shipbuilding in July.—So far as the present year is concerned the figures for July exceed those of all the other months excepting May, one specially gratifying feature being the increase in the output of new mercantile shipping from the various yards available for such work. Compared with pre-war figures the total tonnage of 16,722 tons is remarkably small, and the aggregate tonnage for the seven months is just over 90,000 tons. However, if things continue to move as they are doing it is quite apparent that a visible improvement will be observed before very long, which, should nothing untoward happen, will help to set mercantile shipbuilding more on the level of former times. In all the yards work is proceeding most satisfactorily, although no new contracts have been placed during the month. The following table shows the launches from the four principal Scottish rivers during July:—

Clyde.		Forth.		Tay.		Dee.	
Vessels.	Tons.	Vessels.	Tons.	Vessels.	Tons.	Vessels.	Tons.
11	16,722	2	508	2	550	3	600

UNITED STATES STEEL CORPORATION.—The United States Steel Corporation is about to commence constructive operations at Ojibway, Ontario. The construction to be undertaken this year relates to docks and other preliminary works; the construction of steel works, properly so-called, will not be undertaken to any considerable extent before 1917.

THE CITY AND GUILDS OF LONDON INSTITUTE.—The department of technology of the City and Guilds of London Institute have just issued their 1916-17 programme for technical classes. It will, of course, be impossible under existing conditions for the number of students to be maintained, since large numbers have joined the army and others are working overtime on munitions. It is nevertheless important that the work be carried on, and no reduction has been made in the number of subjects in which examinations will be held, which is 79, provided that at least 10 candidates offer themselves in any subject. Copies of the new programme, price 9*d.*, can be obtained from any bookseller, or from the publisher, Mr. John Murray, Albemarle street, London.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

Blast Furnaces in Operation.—A commencement has, at length, been made with the re-starting of blastfurnaces that have been idle for some time past, one having been put into operation at Warrenby. This brings the total blowing on the North-East Coast up to 70, of which 31 are manufacturing hematite iron, 28 are making Cleveland pig, and 11 are producing special kinds of iron. The furnace that has just been re-lighted is running on hematite. Preparations are well advanced for the re-starting of other idle plant.

Cleveland Pig-Iron.—Buyers of Cleveland pig-iron, on both home and foreign account, are much in evidence, but they experience great difficulty in placing orders, there being practically no free iron, and makers having committed themselves as far ahead as they care to. For home consumption No. 3 Cleveland pig is 87*s.* 6*d.*, and that price also rules for No. 4 foundry and for No. 4 forge; whilst No. 1 is put at 91*s.* 6*d.* For export No. 3 is 97*s.* 6*d.*; No. 4 foundry, 96*s.* 6*d.*; No. 4 forge, 95*s.* 6*d.*; and No. 1 round about 102*s.* 6*d.*

Stocks of Cleveland Pig-iron.—The stock of Cleveland pig-iron in the public warrant stores here has now been reduced to 21,317 tons, consisting of 20,931 tons of No. 3 quality and 386 tons of other descriptions of iron deliverable as standard. Since the beginning of the month 2,499 tons of No. 3 have been withdrawn, and 16 tons of standard iron have been added, a net decrease of 2,483 tons.

Hematite Iron.—The hematite branch of the staple industry is strong but inactive. Iron is almost unobtainable for anything like early delivery, the situation not having appreciably been relieved by the re-starting of a furnace. Producers have sold well over the next month or two, and are not disposed to make further contracts. For home use and for shipment to France Nos. 1, 2 and 3 remain at 122*s.* 6*d.*, and for general export 140*s.* and upward is quoted.

Shipments of Pig-iron.—Shipments of pig-iron from the port of Middlesbrough, though considerably below what could be wished, are up to expectation, and under the conditions prevailing must be regarded as satisfactory. Loadings so far this month amount to 14,562 tons, as compared with 15,229 tons to the same date last month, and 11,183 tons for the corresponding part of August last year.

Coke.—Coke is a good deal more plentiful, and to meet increasing local requirements preparations are being made for re-starting some of the old beehive ovens. Sellers, however, show no signs of making concessions, and the maximum quotations for home use still rule. Average blastfurnace qualities stand at 28*s.* at the ovens, and up to 30*s.* 6*d.* at the ovens is named for low phosphorus kinds.

Foreign Ore.—Sellers of foreign ore continue to take a firm stand, and values are upheld notwithstanding the very heavy imports on running contracts, and the consequent steady accumulation of the now very considerable stocks. Imports for August are likely to constitute a record. Already this month the unloadings amount to no less than 49,186 tons. With best Rubio approaching 21*s.* f.o.b. Bilbao, and the freight from that port 19*s.* in the open market, the ex-ship Tees quotation should be in the neighbourhood of 40*s.*, but on the basis of the official 17*s.* freight Bilbao-Middlesbrough, the rate at which controlled consumers are still privileged to arrange conveyance, 38*s.* was the ex-ship Tees price of Rubio of 50 per cent. quality.

Manufactured Iron and Steel.—Very little new is ascertainable concerning the various branches of the finished iron and steel industries. Government work still absorbs the attention of manufacturers, and little attention is paid to ordinary commercial business. Quotations are very strong. The following are among the principal market rates:—Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; best best bars, 14*l.* 10*s.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 17*l.* 10*s.* to 18*l.* 10*s.*; packing iron and steel (parallel), 10*l.*; packing iron and steel (tapered), 12*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.*; heavy steel sheets, 18*l.*, 15*s.* to 19*l.*; steel hoops, 16*l.* 10*s.*; steel strip, 17*l.*; steel joists, 11*l.* 2*s.* 6*d.*; heavy sections of steel rails, 10*l.* 17*s.* 6*d.*; and steel sleepers, 12*l.*

NOTES FROM THE SOUTH-WEST.

Cardiff.—The position of the steam coal trade has continued difficult, as uncertainty has prevailed as to the extent to which miners worked on Monday and Tuesday. It was known that the men at most of the collieries would work and all the pits were open at the request of the Government; but it was feared that a number of miners who had already gone away would be absent, so that outputs would be materially reduced. Colliery owners were still unable to offer supplies except "oddments," as the authorities are reserving all available coal until their requirements have been satisfied. Many buyers are still pursuing a waiting policy in the hope of obtaining easier conditions later on. The best Admiralty large steam coal has been, to some extent, nominal; secondary qualities have made 37*s.* to 39*s.*; Monmouthshire Black Veins, 38*s.* 6*d.* to 39*s.*; ordinary Western Valleys, 38*s.* to 38*s.* 6*d.*; Eastern Valleys, 35*s.* to 37*s.*; best bunker smalls, 27*s.* to 29*s.*; and cargo smalls, 20*s.* to 22*s.* per ton. In bituminous coal best households have made 25*s.* 6*d.* to 26*s.* 6*d.* at the pits; No. 3 Rhondda large, 37*s.* to 38*s.*; smalls, 29*s.* to 31*s.*; No. 2 Rhondda large, 33*s.* to 34*s.*; and No. 2 smalls, 22*s.* to 23*s.* per ton. The latest quotation for patent fuel has been 45*s.* to 50*s.* per ton. Special foundry coke for export has brought 62*s.* 6*d.* to 63*s.*; good foundry coke, 60*s.* to 62*s.* 6*d.*; and furnace coke, 50*s.* to 55*s.* per ton.

Western Trade Matters.—At the annual meeting of the Gloucester Railway Carriage and Wagon Company, Limited, the chairman (Mr. Vassar Smith) stated that 900 members of the company's staff had gone to the war and that 43 of them had been killed. The directors had been able to fill up some of the gaps, but their total strength was now only about 1,200 men, as compared with the usual 1,800. The company had now to obey the Minister of Munitions; and this being the case, the profits from rents and other sources of income might be regarded as satisfactory, especially as nearly £5,000 more had had to be paid for coal and coke.—The Rhondda and Swansea Bay Railway Company has announced an interim dividend of 5 per cent. upon its ordinary shares for the past half-year.—In connection with shipments of coal to France it has been agreed that July licences shall be available for the loading of all steamers which commenced loading before midnight on Saturday, August 5. Under this arrangement, these steamers will be allowed to complete and clear, although their loading may not be completed until subsequently.—An interim dividend at the rate of 5 per cent. per annum has been announced on the ordinary shares of the Bristol Tramways and Carriage Company for the half-year ended June 30; the corresponding interim dividend 12 months ago was at the rate of 4 per cent. per annum.—The Lords of the Treasury have authorised the Ebbw Vale Steel, Iron and Coal Company, Limited, to issue 250,000 ordinary £1 shares to the holders of existing preference and ordinary shares for the purpose of financing the recent and prospective expansion of the company's undertaking.—The directors of the International Coal Company, Limited, Cardiff, report a balance of £21,244 available for dividend for the year ended June 30, after provision for excess profits tax. The dividend for 1915–16 has been fixed at 15 per cent. per annum, as compared with 12½ per cent. in 1914–15 and 5 per cent. per annum in 1913–14.—A coal steamer building at Middlesbrough, and to carry 7,250 tons deadweight, has been sold for delivery at the end of this year to Mr. R. W. Sutherland, Cardiff; the purchase price named is 132,500*l.*—Hills Dry Dock and Engineering Company, Limited, has declared a dividend of 10 per cent. for the past financial year, 2,099*l.* being carried forward.—Insoles, Limited, gives its ordinary proprietors 20 per cent. for 1915–16, as compared with 10 per cent. in 1914–15, 6 per cent. for 1913–14, 7 per cent. for 1912–13, and 10 per cent. for 1911–12.—The Windsor Steam Coal Company, Limited, has entered the dividend-paying list, the directors having decided to distribute the dividends accruing upon the 10 per cent. preference shares for 1911, 1912, 1913 and 1914.—The Newport Gas Company proposes to advance its charges for gas if the recent advance in coal is maintained.—Warrants for an interim dividend at the rate of 20 per cent. per annum were posted by the Maindy Shipping Company on Saturday.—Lord Rhondda has intimated that he knows nothing about negotiations reported to be proceeding in London respecting the future of the London and Northern Steamship Company, Limited.—At a special meeting of the executive of the Swansea Harbour Trust on Thursday, Sir Griffith Thomas presiding, a committee of seven was appointed to confer with Mr. Law respecting future management, and to report before Mr. Law's recent notice of retirement expires.—Mount Stuart Dry Docks, Limited, has declared dividends of 6 per cent. for the year on the preferred ordinary shares and 7 per cent. per annum upon the deferred ordinary shares, carrying forward 28,928*l.*—The Consolidated Cambrian, Limited, has increased its ordinary interim dividend from 10 per cent. per annum to 15 per cent. per annum.—The interim dividends upon the ordinary stocks of the Great Western Railway come out as follows for the first halves of the last five years:—1911–12, 3½ per cent. per annum; 1912–13 and 1913–14, 4¼ per cent. per annum; 1914–15 and 1915–16, 4 per cent. per annum.—A suitable site has been secured for new steel works near Cardiff.—The ordinary stock interim dividend of the Rhymney Railway is proposed to be at the rate of 8 per cent. per annum.—An Order has been made by the Board of Trade requiring the business of Hugo Shrines, Limited, to be wound up; the company was a coal-exporting concern identified with German interests.

PHOTO-VOLTAIC CELLS.—A paper on "Preliminary Notes on a New Way of Converting Light into Electrical Energy," presented in June last to the New York Electrical Society by Mr. Theodore W. Case, reads as if the author had never heard of photo-galvanic cells, nor of the much more studied photo-electric effects. If that be so, Mr. Case has, by a creditable line of experiments, rediscovered some of the peculiar effects that light produces when falling on metals which have been known since the days of Becquerel and Hallwachs. Case placed two electrodes, *e.g.*, copper plates, the one oxidised (simply by heating in a Bunsen flame), the other polished, in an electrolyte (diluted solution of sodium chloride) so that the sunlight fell on the oxide plate, but not on the other, and he obtained currents of about 0.1 ampere at 0.1 volt. Similar cells were studied in this country by Minchin in 1891. The observation recorded by Case that the insulated plate might be painted over without stopping the effect of the light is probably novel. If he can construct photo-galvanic batteries which will give currents of some amperes for months and will not be subject to the fatigue and chemical deterioration which so far have interfered with the use of those cells, he will have achieved something useful.

THE SALVING OF THE STEAMSHIP "LEANDER."

(*For Description, see Page* 128.)

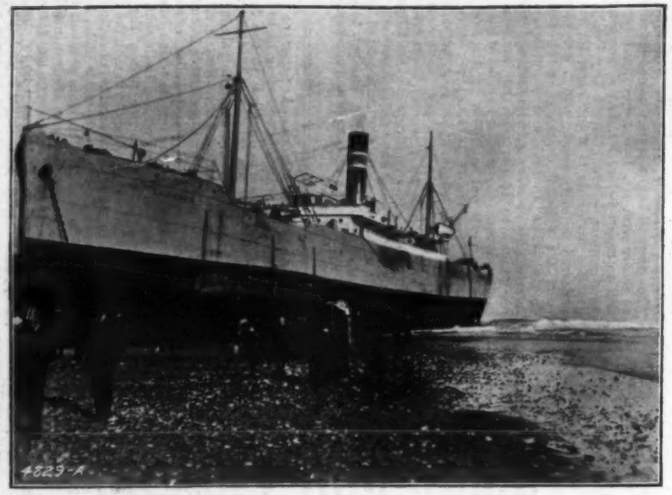


FIG. 1.

FIG. 2.

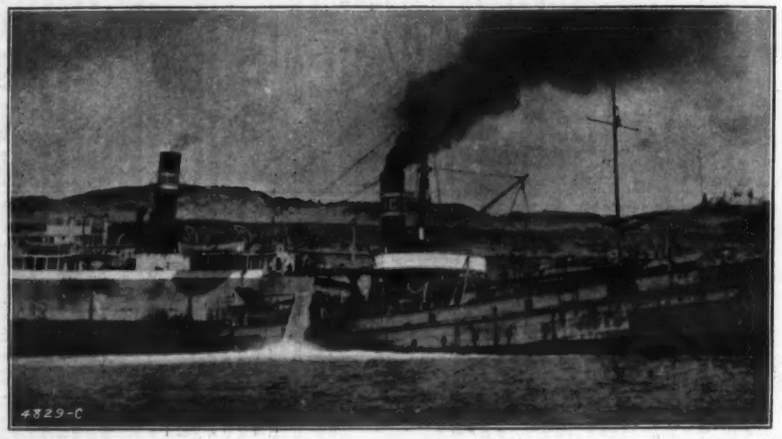
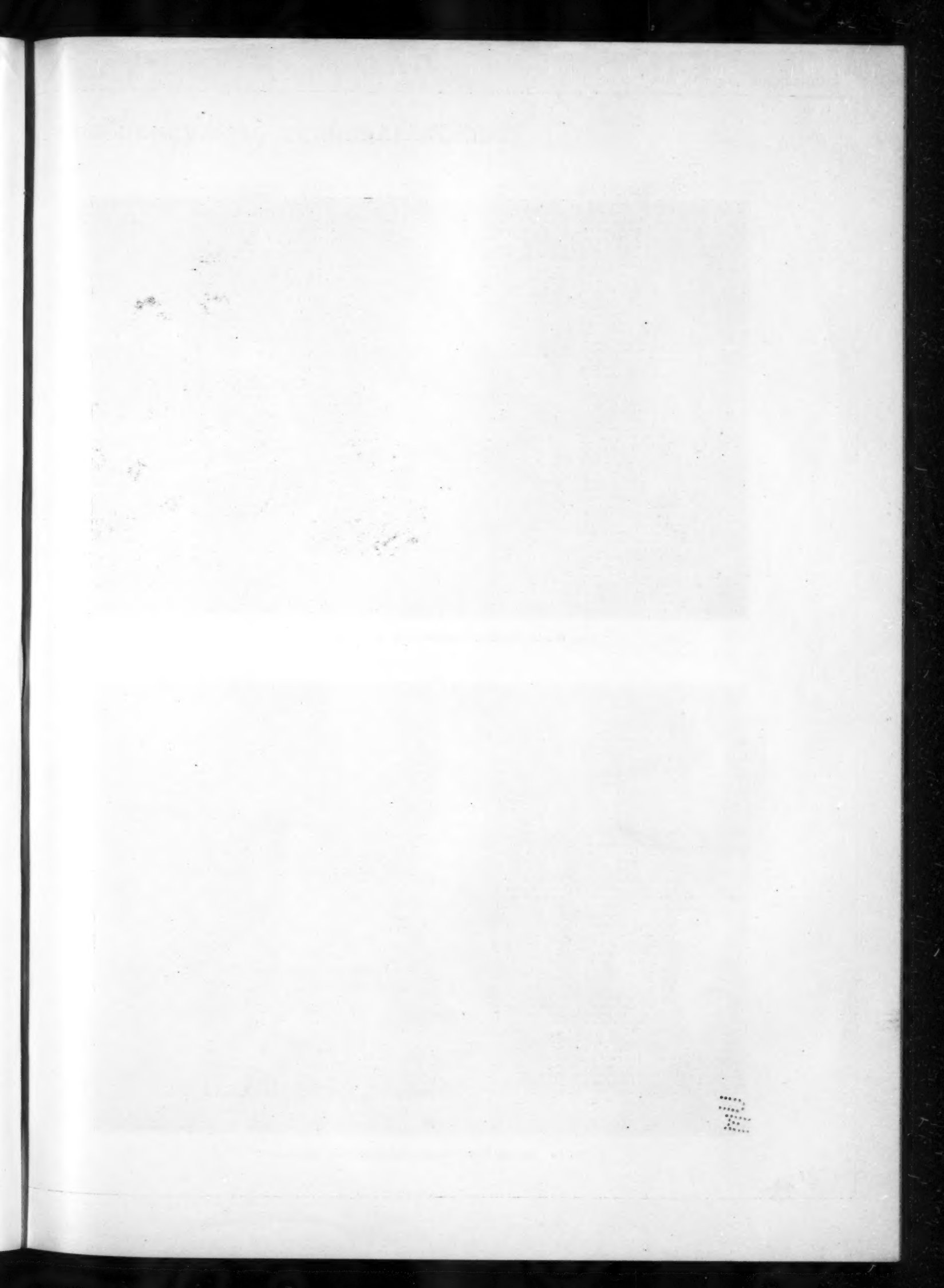


FIG. 3.

FIG. 4.

ELECTRICAL COMBINE IN NORWAY.—The Norwegian Motor and Dynamo Factory, Hasle, near Christiania, and the old firm of Per Kure have been amalgamated under the style of Per Kure, Norwegian Motor and Dynamo Factory, with a capital of 110,000*l*. The new company has taken over the representation of the General Swedish Electric Company.

THE GERMAN CEMENT INDUSTRY.—The export of German cement has almost entirely ceased, and the demands of the building trade have been reduced to a minimum. Some months ago an attempt was made to create a union comprising the whole of Germany's cement industry, but these endeavours proved futile. The interests of the industry in the different parts of Germany were found to be too divergent, and the matter was left to the separate smaller district unions. In the meantime the Government has interfered, and has prohibited all contracts for periods extending beyond December 1 of the current year and all extension of existing works and all new plant. As a result the different unions have again taken up the idea of forming a syndicate for the whole of Germany in order better to protect their interests. These negotiations are now proceeding, and in the meantime it has been stated that the Government may resort to the compulsory formation of a general syndicate, if the industry cannot itself succeed in forming one. This plan is being greatly resented by the works.



THE ARRANGEMENT OF MACHINE-SHOPS; THE S

(For Description, Page 1

Fig. 12. General View of Large Bay of Machine-Shop.

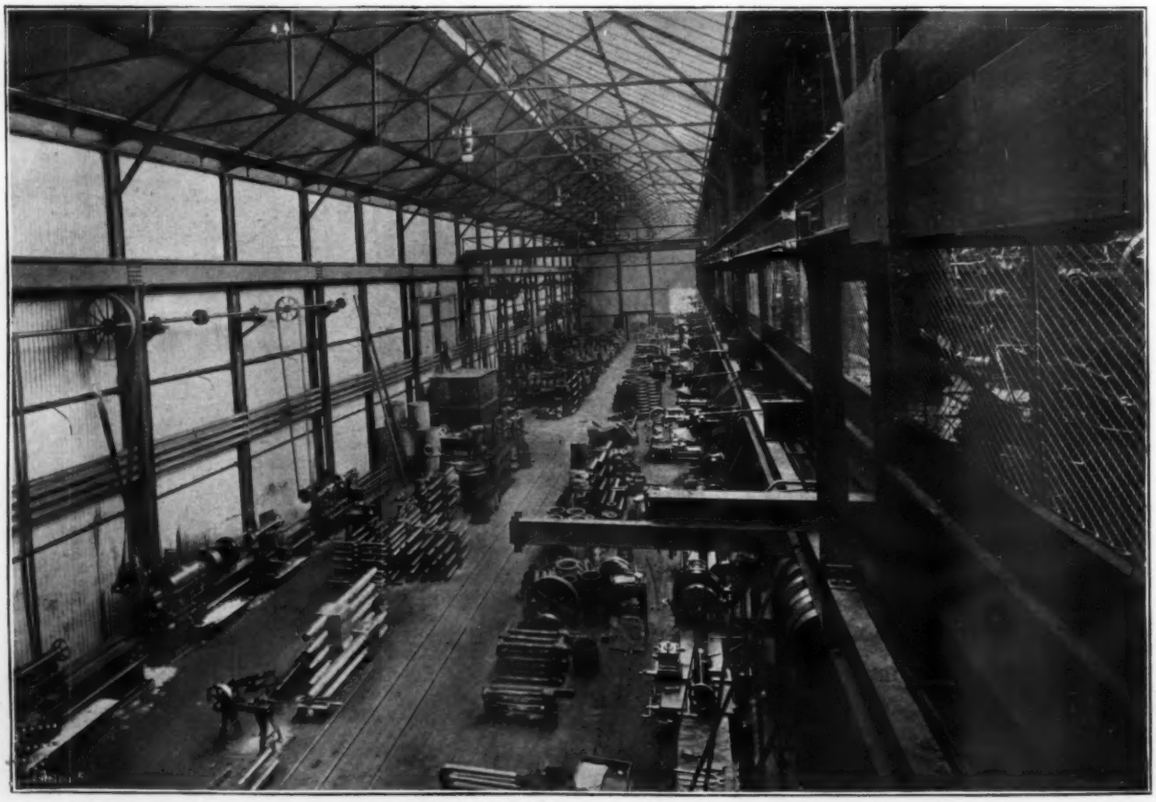


Fig. 13. Another View of Large Bay taken from the Gallery.

S; E SHOPS OF MESSRS. PETTERS, LIMITED.

escripti Page 121.)

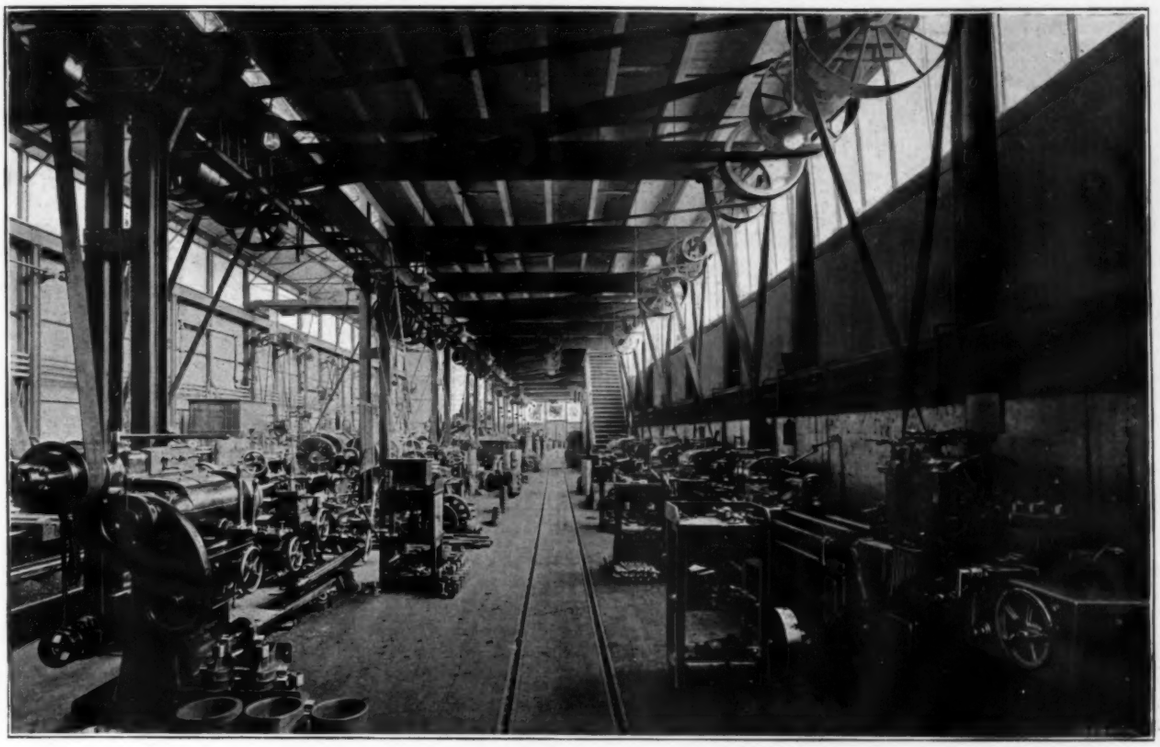


FIG. 14. VIEW OF NARROW BAY OF MACHINE-SHOP, UNDERNEATH THE GALLERY.

FIG. 15. VIEW TAKEN IN THE GALLERY.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

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We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

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TELEPHONE NUMBERS—3663 and 8596 GERRARD.

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ENGINEERING.

FRIDAY, AUGUST 11, 1916.

ORGANISING INDUSTRY.

WE have had a spate of oratory on the subject of trade after the war, and of the making of books relating to the matter there seems no end. But the time has come for action rather than words. This is especially so as there seems remarkable agreement not only on the need for action, but on the general lines to be followed. As in the case of all problems of wide scope affecting many and varied interests, the settlement of details must necessarily involve differences and difficulties. There are possibilities of friction, because the line of policy so materially affects preconceived ideas, and even principles tenaciously held prior to the war. It is contended that we must have a clean slate, and it is important that what is to be written on that slate to take the place of the traditional policy and *laissez-faire* of the past shall be arranged with the greatest care in order to secure the fullest advantage to the State with the greatest degree of harmony amongst contending classes, and with the least possible interference with individual freedom. Action towards organising our industries for maximum efficiency after the war must be taken respectively by the Government in the interests of the nation, by each trade in the interests of its own industry, and by each individual in order that there shall be subjection of the individual for the benefit of the State. All three are correlated, and in no way need they be antagonistic.

The Government line of action was determined by the Conference in Paris of all the Allies in order to secure unity of action as well as of purpose. The resolutions arrived at have been very widely approved, although they involve departure for a time at least from traditional principles in connection with international commerce. In view of the general acceptance of the principle, there is some measure of impatience owing to a doubt as to whether the Government are acting with sufficient promptitude in arranging for the carrying into effect of the resolutions and the establishment of the necessary machinery for the purpose. Success depends in such cases upon detail. In some instances legislation is necessary. Everyone knows that Parliamentary Bills dealing with details are accepted by the House of Commons as a cause for extensive, and oftentimes profitless, debate. It would be well, therefore, that where legislation is necessary action should not be delayed. In other cases, where power to act exists, it should be possible to disclose the nature of the procedure arranged for, and otherwise to create at once the necessary machinery for giving effect to the decisions of the Paris Conference. Mr. Asquith, in the House of Commons on the 2nd inst., dealt with the whole subject on broad lines, and indicated certain directions in which action is being taken. But we agree with Sir Edward Carson that there was room for fuller exposition as to the methods of carrying into effect the economic policy laid down by the Allies.

The abolition of "favoured nation" treatment for our enemies, either in any treaty of peace or in any commercial agreement for many years, is in itself a simple matter; but it is not so with the necessary "permanent measures of mutual assistance and collaboration among the Allies." Each of the Allied States is free to determine what these permanent measures shall be, but the Paris resolution gives suggestion as to some of them. It is stated that the Allied nations "may, for example, have recourse either to enterprises subsidised, directed, or controlled by the Governments themselves, or to the grant of financial assistance for the encouragement of science and technical research and the development of national industries and resources, to Customs duties or prohibitions of a temporary or a permanent character; or to a combination of these different methods." The Board of Trade, we are told, are actively engaged in devising schemes to render us independent of enemy supplies, such as dyes, spelter, optical glass, &c. A State scheme of scientific and industrial research has been created, and we are glad to learn that the Engineering Committee appointed has got to work and that the Advisory Committee of the Privy Council are receiving their suggestions in a liberal-minded spirit. Beyond this little information was given by the Prime Minister regarding Government action. Mr. Asquith generally, and Mr. Bonar Law in more decided terms, regarded the prospect of dumping of German goods immediately after the war as a serious one, and it would be well that there should be disclosed at once the definite action to be taken to prevent this dumping. The Premier stated that "the Allies are under a bounden duty to take every practical measure to secure for their own use the supplies which are produced in their own territories, and to prevent German control, such as existed in some cases before the war." It would be well to know what "practical measures" have been decided upon, and how they are to be enforced. The war, we are also told, "has opened our eyes to the full meaning of the manifold implications of the German system of economic penetration and commercial and financial control of vitally important industries." Here, again, there is lack of information as to the method to be adopted of ensuring "true, well-grounded, and lasting economic independence." It is known that many committees dealing with specific trades have been organised, and, no doubt, their reports may throw light on the action necessary in the interests of national industry. Committee investigations usually take much time, especially when, as at present, great industrialists, who must necessarily serve on such committees, are so busily employed in connection with the provision of munitions for the Navy and Army. But we hope, notwithstanding this, that the deliberations of these committees will be actively pursued, so that as little delay as possible will be involved in arriving at definite recommendations to the Government.

Apart altogether from State action, much can be done in the various industries towards improving organisation. The Lord Provost of Glasgow, Sir Thomas Dunlop, Bart., has done useful service in inviting the engineers of the Clyde district, to the number of 300 firms, to effect improvements in organisation. Great service can be done by such collaboration. Mr. Asquith himself pointed out that a large number of British industries had shown extraordinary enterprise and resourcefulness since the war broke out. They had interchanged ideas, put into the common stock trade secrets hitherto jealously guarded, and called in all the available scientific and mechanical resources of the country for the purpose of increasing output and improving organisation. We have on former occasions referred to this enterprise and patriotic action. There is undoubtedly much to be derived from the interchange of ideas, and the tendency is increasing to form associations, more or less private, in order to discuss problems of design, and to indicate the directions in which difficulties are to be met so that there will be less duplication of private experimental work. The representative committee appointed at the Glasgow meeting on Friday last is to report as to "the nature, scope and object of an organisation which can deal with the conditions covering the industries in question, and with the Government regarding any measure, old or new, which may affect those industries after the war." Thus their work is associated with the economic rather than the technical question, and it must be admitted that there is room for such independent committees, provided they will make it their business to urge on the Government towards the fulfilment of their part of the undertaking, while at the same time stimulating separate firms towards greater self-reliance and towards the submergence of immediate individual interests in the necessary collective action for the good of the nation.

Perhaps, however, one of the most difficult of all

the problems on which action ought to be taken has reference to the relationship between employer and worker. The Prime Minister, in referring to the fact that our traditional policy of free trade must not be indefinitely maintained if it prevented the defect of German systems of economic penetration, made a remark which is applicable to all the national problems of the moment. He said: "No one who has any imagination can possibly be blind to the fact that this war and all the enormous upheavals of political, social and industrial conditions which it has involved, must in many ways—and ought if we are a rational and practical people—suggest to us new problems or possible modifications in the solutions for old ones. I would regard it as a deliberate blindness to the teaching of experience if we were to say we had forgotten nothing and had learned nothing from a war like this." That is particularly applicable to the problem of the relations between employers and employed. The Government, on the one hand, have in the Munitions Act promised that the pre-war trade-union conditions will be reverted to after the end of the war. The lessons of the war, however, have shown not only that our general economic policy was unsound, but that the restrictive regulations of trade unions precluded the highest efficiency either from the most effective machine tools or the physical effort of the worker. It would be a grave blunder if the lessons of the war, particularly in connection with the provision of war material, were lost by a blind adherence to the promise of the Government in this matter. The subject of the relations between capital and labour is as important as any involved in the reorganising of our industries. The Government, the Prime Minister stated, "are anxiously considering, in concert with the representatives of labour, the outlines and the basis of our post-war policy, both social and industrial, with a view of securing a fairer distribution amongst all classes of the products of our industry." This is a big question which we do not propose here to discuss, but we would urge on those who are "anxiously considering" this question to investigate it in the light of sound economic principles regarding production for the national well-being. If trade unions put an arbitrary restriction on the amount of work which a man or a woman may do in a week, irrespective of improvement in the producing mechanism provided by the employer, the volume of national production must be seriously affected. The employer will cease to have any stimulus towards improving the producing mechanism, and this is one of the most clamant needs of the moment in view of intensified international competition. The method adopted should rather be to ensure a fair standard rate per unit of production per unit of time, with a substantial bonus for the exercise of increased diligence, greater aptitude and keener mental effort proved by increased output. In this way labour would secure a larger share, the volume of output would be increased, the product would be cheaper, and the nation would be in a better position to compete in foreign markets.

REPORT OF THE ADVISORY COMMITTEE ON AERONAUTICS FOR 1915-16.

The report of the Advisory Committee for Aeronautics just issued is a distinctly tantalising document. Previous reports have been veritable store-houses of valuable data and have also contained extremely important papers on various aspects both of theoretical aerodynamics and of practical flight. The report has accordingly in past years formed a somewhat portly volume of two or three hundred pages, freely illustrated throughout. The new report is, however, a mere pamphlet, extending over less than a dozen pages, resembling, in short, rather a preface to a report of the usual kind than the report itself.

The fact, of course, is that the labours of the Committee of the Royal Aircraft Factory and of the National Physical Laboratory have been almost exclusively directed to detailed improvements in our military and naval aircraft. It is evident from the report that very substantial advances have been effected, but for obvious reasons it would be, to say the least, imprudent for the present to publish any detailed description of what has been accomplished. A certain amount of work of a purely scientific character has also been carried out, and particulars of this will, it is stated, be published at a later date. One addition has been made to the membership of the Committee during the past year in the person of Mr. Tennyson d'Eyncourt, an appointment which is a natural consequence of the realisation of the fact that naval aircraft promise to play a *rôle* of steadily increasing importance in the future.

Most of the report deals with the work done at the National Physical Laboratory. At the beginning of the year, three air channels were available for experimental work, having cross-sections measuring 3 ft., 4 ft. and 7 ft. respectively. These were found insufficient for the requirements of our naval and military authorities, and a new 7-ft. channel and new 4-ft. channel have been added accordingly. This has necessitated an increase in office and workshop accommodation, and in the *personnel* of the staff. The experience previously gained has made possible a number of minor improvements in these new channels and their accessories. It is of interest to note in this connection, however, that after a careful study of what had been effected in this way in foreign countries the Massachusetts Institute of Technology has adopted for their own work on aerodynamics a replica of one of the channels at Teddington, and the report mentions that drawings of the balance for the 7-ft. channel have been supplied, on request, to the Navy Department at Washington.

One of the most important problems in aerodynamics is unquestionably the law of comparison between a model and its prototype. Eiffel, it will be remembered, found that the law of resistance of falling spheres appeared to change with the size of the sphere, and Lord Rayleigh pointed out that this was to be expected from theoretical considerations and showed that certain of the resistances, at any rate, would be identical in experiments with different models whenever the ratio $\frac{v\,l}{\nu}$ was the same. In this expression v denotes the speed of motion, l the length of some homologous dimension of the models, and ν the kinematic viscosity of the air. The completion of the new 7-ft. tunnel has made it possible to increase substantially the range of this ratio. Amongst the experiments made in the tunnels has been a series on the resistance of struts and wires. These have shown that the R.A.F. wires offer little or no greater resistance to the air than stream-line forms, and as they are much easier to make and employ, their use has been standardised. It has been found advisable to adopt universal joints at the end fittings as an additional precaution against the effects of vibration, which have been serious when the natural periodicity of the part affected has chanced to synchronise with the rate of revolutions of the engine.

Factors of safety have been revised. As is well known, there is no *à priori* method of fixing these, but a minimum factor of safety of 6 was adopted provisionally. This has had to be substantially reduced in some cases in order to secure the desired speed and climbing capacity. This decrease, of course, makes it imperative to diminish as far as practicable "the factor of ignorance," and the report states that much has been done during the year in improving methods of calculation.

The new wing sections, devised as the result of the further knowledge acquired, have increased the capacity of the flying machine for a given weight and engine power. Particular attention has, it appears, been paid to improvements in the landing gear, an air and oil buffer being introduced in the case of larger machines.

The fabrics used in covering wings have received careful study. An interesting point established is that the actinic rays of the sun are in the main responsible for the deterioration of these coverings, with time; and by adding a suitable pigment to the varnish the rate of decay can be greatly reduced. This addition, moreover, it is stated, greatly diminishes the visibility of the machine in flight. A non-poisonous dope has also been discovered.

The work at the National Physical Laboratory has included a comparison of propeller tests made in wind channels and with a whirling machine. The two methods are stated to be in accord, but it has been decided in the future to make the tests mainly in the air channels as involving less time and labour. Aeronautical engineers will await with impatience the time when circumstances will admit of the publication of details of these many researches, but the work of the Committee has also included investigations into other matters less strictly aeronautical in character. The aerodynamic properties of bombs have been studied with a view to increasing the accuracy of fire, and optical apparatus has been devised for facilitating the observation of results. The designs of magnetos, sparking-plugs, of special shells, and of gun mountings have also been studied, in addition to many associated problems. No doubt some portion of the present mastery of the air which our aviators at the front have secured is to be attributed to these researches, though the main credit is due to the courage and enterprise of the pilots themselves, their ascendancy being fully as much moral as material.

THE PRINCIPLE OF RELATIVITY.

Man in a philosophical mood readily concedes that everything is relative. The boy who, by performing jumping exercises on a moving stairway, manages to remain at the same level, feels that it may require hard work to keep relatively at rest. How the astronomer can correctly predict the moment of an eclipse, though the earth rotates and revolves round the sun, and the moon describes its orbit subject to complex perturbations, is a matter of wonder to most people. That such problems concern the principle of relativity is an old story, of course. Within the last decade, however, that expression has assumed a definite meaning, and the reader who wishes to inquire into it is at once confronted not only by pages of abstruse mathematical deductions, which he expected to have to face, and by four-dimensional co-ordinates, but also by references to Newtonian mechanics, the Lorentz contraction, the Michelson-Morley experiment, non-Euclidian geometry, &c., the immediate relevancy of some of which he hardly understands. Though the principle creeps up in many scientific memoirs, the literature on the subject speaks of the electrodynamics of moving systems rather than of relativity.

The term "principle of relativity" first occurs, we believe, in the philosophical writings of William Hamilton, the metaphysician of Glasgow and Edinburgh, who died in 1856—not to be confounded with his contemporary, the great Dublin mathematician, William Rowan Hamilton. According to Hamilton, relativity is a general condition of the thinkable, and quantity has three phases: Time (protensive), space (extensive), degree (intensive). The modern conception of relativity confines itself to movements in space and time. Professor A. Einstein, now of Berlin, whose "Electrodynamics of Moving Bodies" (*Annalen der Physik*, 1905) initiated the present relativity movement, is in these, as in other fundamental investigations (*e.g.*, the quantum theory), associated with his colleague, Professor M. Planck. To have clearly laid down the inseparability and formal equivalence of time and space in physical research is the merit of the late Hermann Minkowski, a brilliant young mathematician of Göttingen, who died in 1909, before some of his best work was published. If we add the names of Dr. M. Born and of Mr. E. Cunningham, of Cambridge, we have almost exhausted the list of the chief workers on relativity, apart from mathematicians like Grossmann, Civita-Levi, Poincaré, Ricci, who have developed new mathematical lines of attack, and physicists like J. Laub, who reviewed the experimental basis of the theory, beginning with Bradley's determination of the aberration of light.

"Philosophically the motion of a body is unintelligible except in reference to some other body. Yet in dynamics the first thing done is to specify the motion of a body without reference to the other body (Larmor)." When formulating his laws of motion, Newton postulated an absolute frame of reference for the position of a point, and it seems possible to choose a frame such that Newton's laws accurately describe the motions of material systems. The position of a

point is commonly referred to an orthogonal system of axes, X Y Z; an event is said to happen t time-units after another. Newton's laws show invariance in two respects: The form of the equations remains unchanged, (1) for zero time when the orientation of the system of co-ordinates is changed, that is, when the system is turned about its origin; transformations of this group are considered to establish the fundamental character of space (Minkowski). The forms of the equation allow (2) of imparting uniform translation to the system, when the co-ordinates x, y, z pass into $x - \alpha t$, $y - \beta t$, $z - \gamma t$. "Transformations of this second group are rather shirked, because we can never decide in physical phenomena whether the space, considered to be at rest, was not in a uniform motion. Thus the two groups remain separated. But all our observations are bound to space and time. Nobody ever saw a place except at some definite time, nobody ever noticed a time except at some place. Three-dimensional geometry must give way to four-dimensional physics; we should discuss, not places or events, but point-events. If we were able to trace the dx, dy, dz, dt of any point through space and time, we should have the 'life or world-line' of the point, and the universe would be resolved into world-lines (Minkowski)." To mark the inseparability of space and time, scientists sometimes designate the axes x_1, x_2, x_3, x_4 instead of X, Y, Z, T.

In formulating the principle of relativity Einstein demanded that the laws of motion should be framed independently of the system of reference—provided, in the first instance, that the various systems of reference are to one another in uniform (not in accelerated) motion. This provision was first stipulated lest the problems become too complex. Recently the general laws of motion have been expressed by equations which remain co-variant for all transformations, and Einstein distinguishes in this sense the "general" principle of relativity—dealing also, *e.g.*, with gravitational problems—from the first "special" principle. Why do the Lorentz contraction, the electromagnetic theory, &c., at once enter into the problem? The electromagnetic theory of Maxwell and Hertz seemed to promise, in the all-pervading æther, an ultimate system of reference relative to which velocities might be specified. Different scientists advocate different æthers, and in most systems of electrodynamics and optics the mobility of the æther plays an important part. The æther may (1) be free and in absolute rest, not influenced by moving bodies; (2) it may adhere to matter and be carried away with it; (3) it may partake of both these properties. In his "Theory of Electric and Optical Phenomena of Bodies in Motion," H. A. Lorentz (Leiden, 1895), with many other scientists, assumed the æther to be at rest. It seemed possible then to establish a case of absolute motion, a velocity of the earth with regard to the æther. Attempts to establish that motion had been made before that time, notably by Michelson and Morley since 1886, but they had as completely failed to give evidence of such a velocity as dynamical science had failed to give evidence of an absolute velocity of a material body in space. Now Lorentz proved (in the paper mentioned) that the looked-for influence of the motion of the earth on optical phenomena should, indeed, *not* have been observed if, in his formula, the term v/c (v velocity of the earth, c velocity of light) were alone considered, but that a second-order effect v^2/c^2 should have been observed. But Michelson and Morley did not find either when determining the velocity of light in the direction of the motion of the earth and in the opposite direction.

To help over the difficulty the late G. F. Fitz-Gerald and Lorentz suggested that a body in motion would be contracted, in the direction of the motion, in the ratio $1 : \sqrt{1 - v^2/c^2}$. The suggestion looked arbitrary and to be made merely to save a theory: "However extraordinary this hypothesis may appear, it is by no means gratuitous, if we assume that the intramolecular forces act through the mediation of the æther in a manner similar to that which we know to be the case in electric and magnetic forces. Form and dimensions of a body are determined by these forces, but, of course, the elongation or contraction is extraordinarily small; it would increase or shorten the diameter of the earth [roughly 8,000 miles] by about 6½ cm. (Lorentz)." The belief in this remarkable property of the electromagnetic field (Voigt, Larmor) has been much strengthened since, and it forms, in fact, the mathematical foundation for the principle of relativity. Yet the contraction remains startling. It signifies that the dimensions of a body change with the velocity assigned to it; measurements of the time interval between two events at the same point would similarly be affected. In addition to the first-order Doppler effect (due to the motion of the source of light in the line of sight) a second-order effect (at right angles to the motion) should be observable, and search for it has been made by Laub. On the other hand, Einstein has shown that, when the "local time" of Lorentz is simply defined as time, the contraction appears as a necessary consequence of the relativity principle. But he has to modify his conception of the æther; his electromagnetic fields are not conditions of matter, but things of independent existence, akin to ponderable matter and having inertia like it.

Mere equations of free space cannot lead to any tangible results. Man is concerned with material phenomena, and the observation of the propagation of light is only possible when light meets matter. The most widely accepted theory of matter is the electronic theory; thus we come to the material point—the electron. Examining the experiments of Kaufmann and Bucherer on the variability of the acceleration of β rays of different velocities in the same field, Einstein discovered indeed a slight but systematic deviation of the experimental from the theoretical curve, which was one of the reasons inducing him to generalise the relativity theory.

A uniform translation is not the only one which might be concealed in an electromagnetic field. Acceleration of one system with regard to another might also be concealed, though the magnetic effect produced by a rotating sphere would, *e.g.*, be observable by an instrument carried round with the sphere. Such considerations lead to modifications of the meaning of mass, momentum, kinetic energy and of the nature of gravitation. According to Einstein, the inertia and internal energy of a system are of the same kind; the mass m would correspond to the energy mc^2 (c=velocity of light), and the astounding energy of radioactivity would only represent a small fraction of this store of energy; a radiation confined within a closed space would possess, not only inertia, but also weight. The mathematics of these relations can be understood only by the mathematician. But we may say a few more words concerning measurements of length and time and the constant vacuum velocity c of light which these considerations involve.

The principle of relativity can, from known phenomena in a given system, furnish information as to the corresponding phenomena in the same system supposed to be as a whole in uniform translation. But the principle does not tell us the influence of system A on system B, when B is moving relative to A, from a knowledge of that influence when the two systems are relatively at rest. That fact is closely associated with the already-mentioned fact that events appearing simultaneous to one observer are not necessarily simultaneous to another.

On the ordinary view the specified points of a system at rest are at a definite distance apart, independent of orientation in space; events are equally independent of orientation in time. The theory of relativity does not accept that. Requiring some method of setting two clocks relatively to one another, it assumes that the clocks could be so set, that the velocity of propagation of light *in vacuo*—measured by means of these two clocks—is everywhere equal to a constant c. Let the points A and B, relatively at rest, be provided with clocks at distance r, and let t_A be the time of the clock A when a ray of light reaches A in the direction A B (through vacuum), and let t_B be similarly defined, then $r/(t_B - t_A)$ is always to be equal to c. This principle of the constancy of the velocity of light is by no means self-evident. Einstein considers that it has experimentally been demonstrated. We shall revert to this statement. A clock at point P, which has the gravitation potential ϕ with regard to the origin of the system, will run at a rate by $(1 + \phi/c^2)$ quicker than the clock at the origin. One of Einstein's similia is the following: Let K be a Galilean system of reference (*i.e.*, a system relative to which a mass at sufficient distance would move uniformly in a rectilinear path), and let K_1 be another, rotating at uniform rate about the common Z axis of the two systems. Let a circle be described about the common origin with unit radius in the plane X Y; it will also be a circle in X_1 Y_1. Now measure the ratio: circumference to diameter, with a rule at rest respectively to K; in the first case the ratio will be π, in the second case it will be greater than π. We recognise this when we consider that (judging from K) the circumference rule (but not the radially-applied rule) will have undergone a Lorentz contraction. With regard to K_1, Euclidean geometry will not be applicable, and the path of a ray of light cannot be straight (but must be curved), since the light is to be propagated at a uniform rate in a rectilinear path with regard to K. Nor can we introduce into K_1 a clock of the same nature as the K clock and at rest with respect to K. To understand this, imagine a clock or watch W at the origin, and another W_1 on the circumference of the circle and looked at from K; watch W_1 will appear to lag behind W because it is being carried round; the observer will think that the rate of motion of a clock depends upon the position in space. Thus space and time cannot be so defined that differences of space and time can directly be measured with the aid of the unit rule and standard clock. Let, further, K be a system at rest, K_1 a system at uniform acceleration with regard to K; outside K_1, B be a body having uniform acceleration with regard to K_1. Can the observer, moving with K_1, know that he is in accelerated motion? Einstein answers, "No." For the behaviour of B could also be explained by the following argument: The system K_1 is not accelerated, but there is a gravitational field in K_1 which imparts acceleration to B.

As regards gravitation—which has the remarkable property of imparting the same acceleration to all bodies—the theory of relativity concludes that the Newtonian law cannot be exact, but that it can be made exact in many various ways. "If gravitation is to be included in an electromagnetic scheme of matter, it must be propagated through the æther with the velocity of light. If, on the other hand, gravitation has nothing with the electromagnetic properties of matter, we shall hardly expect it to conform to the principle of relativity. Just as the Newtonian mechanics break down in the light of the electrical theory, so the latter may become only an approximation, if gravitation is concerned with more remote and yet undiscovered properties" (Cunningham).

Carried to its furthest extent, the principle of relativity would appear to declare that the phenomena do not lead us to any knowledge of a permanent and unique frame of reference relative to which the motions of bodies can be determined. It is a question of particular interest whether experiment can say anything concerning gravitation from the relativity standpoint. W. de Sitter (Leiden) has examined two modifications of the relativity laws (due to Poincaré) with respect to planetary orbits. Neither of the two modifications leads to any observable periodic or secular change in the orbits, except possibly in the case of Mercury, where the observed effect might, however, be ascribed to other causes. According to Einstein and the late Schwarzschild (Berlin Academy, 1916), the elliptical orbit of a planet would undergo a slow rotation in the direction of the orbit motion, amounting to 43 seconds of arc per century for Mercury—which figure, they consider, would be in excellent agreement with Leverrier's residual movement of the perihelion of Mercury, for which the attraction of the other planets would not account. De Sitter has further established the constancy of the velocity of light c by observations of binary stars. Ritz had asserted that when the source of light had a velocity u of its own, the light should be propagated at the rate $(c + u)$. Erwin Freundlich questions the validity of this proof and method; he likewise rejects the direct suggestion of Ritz, yet he considers that there might be an effect of some function of u. On the other hand, Einstein calculates that a ray of light passing the sun would be bent through

1.7 seconds of arc, and a ray passing Jupiter would undergo a bending of 0·02 second.

The corrections of physical data, so far due to the principle of relativity, may appear small and insignificant. For the advance of exact science the delineation in clear mathematical terms of what had remained hazy generality or metaphysical speculation is of paramount importance.

NOTES.

Foreign Students at German Technical High Schools.

In Germany the question of foreign labour and foreign students is being eagerly discussed; it has been suggested to tax the former, or rather the employer, according to a sliding scale (the more years the employment lasts, the higher the tax), and no doubt the students will also be dealt with in due course. During the summer term of 1914 there were no less than 7,255 foreign students at German high schools, constituting 7.75 per cent. of the aggregate number of students at the universities and 20.47 per cent. at the technical high schools. This state of affairs has frequently been commented upon by Germany, and not without serious apprehension, in Parliament, and in the Press. The foreign students, of whom a large proportion came from Russia, had a way of rather crowding together at certain high schools and showed but little inclination to mix with the German students, or to fall in with their views and mode of living. Steps were by degrees taken by the different German States to regulate, if not counteract, this invasion; the foreigners had to pass an entrance examination, they had to pay the highest fees and their admission was made dependent upon all German students first being accommodated. This latter rule did not apply to the technical schools in Prussia, where there has been no question of lack of accommodation, but only to the universities. These restrictions only took effect shortly before the war broke out, and their influence had to be ascertained before new measures were adopted; nor were the authorities concerned all of one mind as to the result of these many foreigners frequenting German high schools. Some held that these foreign students on their return home would prove desirable apostles in the cause of the ever-lauded Germanism and German goods, but the war has probably disillusionised the people holding such views. The advantages, therefore, seem very doubtful, but not so the drawbacks. At the technical high schools the foreign students learnt things, methods of research, methods of work, machinery and apparatus, which enabled them to improve the technical methods of their own country. This more especially refers to the chemical industry, the optical industry, the electro-technical branch and the machine industry. The simplest preventative would, of course, be simply to forbid foreigners to visit the natural science sections of the German high schools, but that on the other hand would mean an undesirable reduction of the revenue. It is, however, proposed, that this difficult problem should be solved by arrangements being made with each individual country as to the conditions under which her subjects can be allowed to study at German high schools. There is no question of reciprocity here, inasmuch as no Germans visit foreign technical high schools, except in quite exceptional cases for the sake of the language, as, for instance, at Grenoble, Lausanne or Geneva. It may be, however, that the foreign students themselves will show no desire to enter Germany after all that has happened during the last two years.

Banded Spectra of Titanium Oxide and Magnesium and Calcium Hydrides.

The title of a paper by Mr. Arthur S. King, of the Mount Wilson Observatory, on "The Production in the Electric Furnace of the Banded Spectra ascribed to Titanium Oxide, Magnesium Hydride and Calcium Hydride" (*Astrophysical Journal*, June, 1916), may almost seem to suggest that the spectra were erroneously ascribed to those compounds. Since all these spectra have been identified with sun-spots, and the titanium flutings have further been considered characteristic of stars of the Antares type (Antarian bands), and since the presence of such spectra is taken as evidence of relatively low temperature, this conclusion would call forth considerable comment. As a matter of fact, Mr. King confirms Professor Fowler's views on titanium oxide which were based on experiments with the arc and spark, and the details of the confirmation are interesting. When the furnace—which is not described—was operated *in vacuo*, the titanium oxide flutings were not seen; nor were they observed when air was admitted, except with a strong current of air or oxygen, the gas being forced in through a silica tube ending in the furnace. Then the bands came out brilliantly. It would appear that an insufficient supply of oxygen is taken up by the carbon of the furnace, and the line spectrum of titanium metal then appears; when there is enough oxygen present to oxidise the vaporised titanium, the line spectrum of the metal disappears, and the banded oxide spectrum appears. When oxygen was blown into the furnace, either the one or the other spectrum could be produced at will. The supply of oxygen hardly affected the furnace temperature—not by more than 50 deg. C. apparently. The bands were strongest at temperatures of 2,300 or 2,600 deg. C. in different experiments, and weakened at higher temperatures, such as can more easily be produced in the furnace than in flames. The bands were relatively stronger at the red end in the furnace than in the arc. When the bands were well developed, the image on the slit looked greenish-yellow, similar to the envelope of a long carbon arc containing titanium. As regards the hydrides, a fluted spectrum was observed when magnesium was burned in a hydrogen atmosphere, even when little hydrogen was present. The previous experiments had been made with arcs, and it was possible that the arc discharge might be modified by the hydrogen atmosphere; it was further possible that acetylene might be generated by the interaction between carbon and hydrogen. Hydrogen was therefore introduced into the furnace chamber through a silica tube; the mode of supplying the hydrogen made little difference. The bands were seen even with moderate percentages of hydrogen, and the dependence of the bands on the presence of hydrogen cannot be questioned. Similar observations were made with calcium, which showed the bands, first studied by Olmsted, best between 1,900 and 2,200 deg. C.; in the case of magnesium temperatures above 2,500 deg. C. were found unfavourable to the occurrence of the bands. It thus appears justifiable to associate the bands with relatively low temperatures.

Increase in Merchant Shipbuilding.

Evidences accumulate to show that operations in the building of merchant ships are increasing at a steadily advancing rate. Not only has building been resumed on a large number of ships on which work was arrested, due to naval demands, but a greater number of ships are being laid down. Consistent with the needs of the Navy, this is a policy which is most desirable, because one of the prime necessities on the declaration of peace will be a great fleet to re-establish our extensive export trade. When the war broke out there were, in course of construction, in the United Kingdom merchant ships (each exceeding 100 tons) with an aggregate gross tonnage of nearly 1,750,000 tons; and although the rate of launching continued for two or three months at the normal rate of over 400,000 tons per quarter, there was, after the beginning of 1915, a sharp reduction to the rate of 146,000 tons per quarter. A steady diminution continued, and in the first quarter of 1916 the tonnage launched was only 80,000 tons. During the past quarter there has been a revival, the output being 91 vessels, of 157,594 tons. Still more illustrative of the increased work being done on merchant ships is the increase in the tonnage being laid down in the shipbuilding yards. Prior to the war from 300,000 to 400,000 tons were laid down per quarter, but this, like the launches, steadily fell off, the minimum being reached in the last quarter of 1915, when only 70 vessels, of 83,656 tons, were commenced. There was an increase in the first quarter of the current year to 55 vessels, of 102,883 tons. In the second quarter of the year there is a more marked improvement, the number of vessels commenced being 84, with a tonnage of 193,719. The actual work on hand has not varied much during the period of war, by reason of the lack of progress of the ships on the stocks. From 1,750,000 tons on hand at the beginning of the war, the total dropped to 1,363,590 tons at the end of last year. Since then there has been an advance, the total now being 1,540,218 tons, the measurement of 440 vessels. This is 117,000 tons more than the aggregate at the end of March, and 177,000 tons more than at the end of December. All the districts participate in this advance, although, naturally, those engaged most largely on war work do not show the same rate of increase. Thus, in the case of the Glasgow district, as shown in Lloyd's latest return, from which our deductions are made, there is a decrease in the merchant tonnage as compared with a year ago from 353,923 to 296,022 tons. In Greenock, however, the tonnage has increased in the year from 209,004 to 238,830 tons. On the Tyne the advance is from 270,854 to 310,577 tons; on the Weir, from 162,836 to 197,359 tons. The Tees has improved its position of three months ago, but is far below the total of a year ago, which suggests that, in the absence of war work, the builders there have been able to turn out a considerable amount of merchant shipping. At Belfast there is an improvement as compared with three months ago, but the figures now—262,050 tons—are practically the same as a year ago. The Hartlepool figures have remained fairly constant, the total now being 69,625 tons. At Hull also there is an improvement, the number of vessels on hand, mostly fishing craft, being 61, and the tonnage 31,428 tons. The figures show that during the quarter there was laid down a vessel exceeding 30,000 tons, while another just under 12,000 tons has been commenced. With these exceptions, all the new vessels laid down have been under 6,000 tons.

LITERATURE.

Hydraulic Flow Reviewed. By Alfred A. Barnes, A.C.G.I., Assoc. M. Inst. C.E. London: E. and F. N. Spon, Limited; New York: Spon and Chamberlain. [Price 12*s.* 6*d.* net.]

This is an important and instructive work, in which the author, Mr. Alfred A. Barnes, by breaking fresh ground and applying old and recent experimental data in a new way, has materially advanced our knowledge of hydraulic flow; and at the same time has put the result of his investigation into very practical form. After a careful study of its contents, we feel sure the book will be appreciated by all engineers who have to deal with the flow of water. By a process of his own discovery, Mr. Barnes seems to have achieved a general success denied to many distinguished men who devoted their best talents to the investigation of the subject. The work is in two parts, with their respective comparative tables of experimental and calculated results, together with an important series of Velocity and Discharge Diagrams at the end.

Part I treats of the Flow of Water in Pipes and Open Channels, and Part II with the Measurement of Water by means of Triangular Notches, Weirs and Circular Orifices.

The first part begins with a reference to a number of well-known formulæ. The list is headed by the Original Chezy formula, viz.:—

$$v = C\sqrt{m\,i}$$

in which C was an invariable quantity. Later investigations, however, proved that C in the Chezy formula was by no means an invariable quantity under the varying conditions of surface met with in practice, and the other formulæ in the list, which are all based on the Chezy one, are given as typical of the lines on which many previous investigators worked, in attempts, which were in varying degree successful, to add to the formula the means of obtaining the value for C suitable to each occasion. All of these investigators, however, adhered throughout to the belief that the coefficient alone was at fault and not the term $\sqrt{m\,i}$. Mr. Barnes, in the work under notice, contends that much valuable labour was lost owing to this wrong belief, the primary error being in assuming that 0.50 was necessarily the correct power of both m and i in all

circumstances, and he goes on to prove that by adopting the general formula,

$$v = K m^{\alpha} i^{\beta} \quad . \quad . \quad . \quad (1)$$

which is based on lines proposed by Hagen in 1854. Constant values of the indices α and β and of the coefficient K can be found for any particular class of pipe or open channel which will render the formula correct for all values of m and i over the widest range in that class. He indicates very clearly how this can be done by a special method of logarithmic plotting. The line of reasoning by which the method is evolved is simple and direct, but we must express an appreciation of the way in which the process is developed and applied.

The velocities obtained by the author's formulæ for widely varying values of m and i in 16 different classes of pipes and channels and those obtained by actual observation are compared side by side in a series of 16 separate tables, the cases being all numbered for easy reference, the authority for the observations given and other necessary details. The general close agreement is very remarkable.

Mr. Barnes rightly lays great stress on the fact that in his investigation no assumptions whatever have been made, his formulæ being wholly based on actual experimental observations in the different classes, and therefore empirical. The task of collecting over 800 observations from different sources must alone have been a laborious one. It was known that the logarithms of the terms in the formula $v = K m^{\alpha} i^{\beta}$, so long as K and the indices α and β remained constant, gave the equation of a straight line. When then the logarithms of actually observed values of v, m and i in different classes of pipes and open channels were plotted as described, it was found that the points corresponding first to the same values of m and next to the same values of i, in each case in the same class, coincided with, or were very close to, a straight line drawn through the average position of the points, and that these lines were not only practically parallel, but also, which is very important, that a definite order of equidistance between these lines obtained. The symmetry of the results in the different classes, slight deviations being, with reason, attributed to errors of observation, proved that Mr. Barnes' contention regarding the general applicability of equation (1) was correct. It only remained to determine for each class the values of the constants α, β and K in the manner explained in the book. Had the points as plotted not come into general line, but fallen irregularly, or had there not been general parallelism in the average lines in each class, then the investigation would have been fruitless. Mr. Barnes is, therefore, to be congratulated on the satisfactory results of his method. Logarithmic plotting had already been applied by others in connection with the problems of hydraulic flow, but the application seems to have stopped short at a point beyond which, for want of certain data, it was thought impossible to make a satisfactory advance. However, Mr. Barnes solved the difficulty by showing that for the purpose required it was not essential in a class to have experimental data for pipes and channels giving the actual values $m =$ 1 ft. or $i = 1$, as, by reason of the established order of equidistance of the lines, the spaces between lines corresponding to other available values of m and i gave a scale on the diagram by which could be fixed the true position of the line corresponding to the value of $m = 1$, or $i = 1$, either position giving the means of finding K.

The rationale of the plain Chezy formula as given in text-books on hydraulics leads to an equation which is fundamental, but one side of which is based on certain assumptions, one being that the resistance to the motion of water caused by the surface friction of pipes and channels is, for the same surface area, proportional to the square of the velocity; another that the velocity of flow throughout a cross-section is to be taken as uniform.

On this basis the resistance, R, over the wetted area swept per second, multiplied by v, the mean velocity, that is, R v, gives the lost work per second due to the resistance, and as the flow is uniform this must be just equal to the work represented by the weight of the volume flowing per second multiplied by z, the drop in gradient or surface level on a length of run $l = n$. If f^1 is the skin friction in lbs. per square foot for a velocity of 1 ft. per second, s the wetted perimeter, A the cross-sectional area of the flow, and 62.4 lbs. is taken as the weight of a cubic foot of water, $R = f^1 s l v^2$ and $R v = f s l v^3$, then we have the equation of work in ft.-lbs.,

$$f^1 s l v^3 = 62.4 A v z \quad . \quad . \quad (2)$$

Dividing by $f^1 s l v$,

$$v^2 = \frac{62.4}{f^1} \frac{A}{s} \frac{z}{l} = \frac{62.4}{f^1} m i \quad . \quad . \quad (3)$$

$$v = \sqrt{\frac{62.4}{f^1}} \times \sqrt{m i} = C \sqrt{m i} \quad . \quad (4)$$

Equation (3) shows the genesis of m and i and the coefficient C of the Chezy formula

In the left side of equation (2) the water is treated as if it were a moving cylinder or block of ice with a film of water between the ice and the sides of the pipe or channel, and lubricating the passage so effectually as to reduce the resistance to that due to fluid friction alone. Hence, under the conditions assumed, m has a merely arithmetical mean value in equation (3), which has no proper relation to the physics of hydraulic flow. In reality the velocity varies throughout a cross section, being a minimum at the sides and a maximum at or towards the centre, the difference on either side of the mean being considerable and this difference again varying with the mean velocity itself. The result is a species of internal longitudinal shearing which produces deformation and at least viscous resistance which affects the mean velocity, so that under actual conditions m has a pronounced physical influence which governs the distribution of velocity throughout the cross section, an influence which, we think, may be properly graduated by affixing to m an initial exponent, $1 + e$, which would always be greater than unity, and might prove to be constant for each particular class of pipe or channel. This exponent would give a higher root index for m in the final equation (4), which is what is required; for it is obvious that in the case of pipes where the factor m is seldom over 1 ft. and is generally the decimal of a foot (often a small decimal) giving to such decimal values a low root index unduly expands the influence of m, while in large and moderately sized open channels, where m is generally much above unity, its proper influence is much contracted by a low root index.

It was to correct the effect of this disproportionate expansion and contraction, due to the invariable adoption of the index 0.5 for m and i, that C required to be changed with m in using the Chezy formula.

The theory of uniform velocity in a cross section on which the left side of equation (2) is based is admittedly very imperfect, but it has hitherto been adopted as sufficient for practical purposes; also on this side the lateral resistance is assumed in all cases to be proportional to v^2, whereas modern experiments have shown this is not true generally, but that it is proportional to v^y where, for different surfaces, y may be sensibly less or more than 2. However, there can be no doubts as to the right side of equation (2), the factors of which are directly ascertainable figures.

As regards lateral resistance, the usual method of finding the value of the coefficient f is to deduce it from the formula :—

$$v = \sqrt{\frac{2g}{f}} \sqrt{m i}$$

by substituting observed values of v, m and i; hence if $\sqrt{m i}$ is an incorrect function of $m i$, the deduced value of f would be incorrect. Then to get a correct value for f^1 we should have to rely on experiments such as those of Froude and Unwin, the results of which agree well. Froude's experiments, being of a more direct character, are perhaps the more suitable, those on boards 2 ft. long being the most applicable, as the case in which least motion was communicated to the still water. For boards covered with tinfoil, calico and coarse sand, the resistances per square foot of surface, reduced to a velocity of 1 ft. per second, were 0.0027, 0.0081 and 0.0102 lb. respectively, the corresponding power, y, of the velocity to which the resistances were approximately proportional being, for tinfoil 2.16, calico 1.93, and coarse sand 2.00. These few cases show in a practical way how the resistance varies with the nature of the surface and that the index y, in v^y, is not always 2.00 as formerly assumed; further that there is no relation between f^1 and y.

Having obtained proper values for f^1 and y in any class, the only doubtful point would be the correct exponent of m in equation (3); but whatever this may be, the value of v will be the product of the $\frac{1}{y}$ root of each of the three factors forming the right side of that equation, and accordingly the index β in Mr. Barnes' equation ought to be the reciprocal of y in each case.

Revising equation (3) in the sense of the foregoing remarks and by putting

$$K = \left(\frac{62.4}{f^1}\right)^{\frac{1}{y}} \text{ and } \frac{\alpha}{\beta} = 1 + e$$

we have

$$v^y = \frac{64.4}{f^1} m^{1+e} i \quad . \quad . \quad . \quad (3A)$$

Therefore

$$v = \left(\frac{62.4}{f^1}\right)^{\frac{1}{y}} \left(m^{1+e} i\right)^{\frac{1}{y}} = K \left(m^{\frac{\alpha}{\beta}} i\right)^{\beta} \quad . \quad (4A)$$

But (4A) is the same as $v = K m^{\alpha} i^{\beta}$, the general equation (1) on which Mr. Barnes works. Below is his first formula with its equivalent, bringing in the exponent $1 + e$,

$$I - v = 174.1\ m^{0.769}\ i^{0.529} = 174.1\ (m^{1+0.453}\ i)^{0.529}$$

$$\text{As } \beta \text{ is } 0.529,\ y = \frac{1}{0.529} = 1.890;$$

$$\text{and } 1 + e = \frac{\alpha}{\beta} = \frac{0.769}{0.529} = 1.453$$

We have not overlooked that in the Table V for double-riveted wrought-iron pipes the index α is less than β, making $\frac{\alpha}{\beta}$ less than unity. It is the only exception in the list of 16 formulæ, and from some rough trials made we venture to think the author could construct an alternative formula for this class in which the value of $\frac{\alpha}{\beta}$ will be greater than unity. The percentage differences for the formula are not so low as in the other tables.

Mr. Barnes on page 24 states that in his formulæ $\frac{1}{K}$ may be taken as a measure of the relative surface friction in each class, but in the following two formulæ,

No. 2 . . . $v = 136.6\ m^{0.600}\ i^{0.512}$

No. 10 . . . $v = 136.3\ m^{0.655}\ i^{0.484}$

the values of K are practically equal; therefore the surface friction ought to be the same in both, yet the root indices of m and i differ considerably. This is an apparent anomaly.

Mr. Barnes intends to prepare a set of large-scale diagrams for all his equations, which will make the work of calculation an easy and an interesting task. The simplicity of the smaller diagrams given in his book must appeal to all, and we think complete diagrams on a large scale are sure to meet a welcome.

Only one formula, Table XVI, is given for rivers and canals, which for values of m from 2 ft. to 11 ft. and slopes of 1 in 5,000 to 1 in 10,000 we find gives results about 4 per cent. in excess of those given by Kutter's formula for a value of $n = 0.025$. In India and Egypt it is found that Kutter's formula with $n = 0.020$ to 0.0225 gives results agreeing well with observations, and that in some canals in India, and in one particularly straight even reach of the Ravi River, observations work out to a much lower value than 0.020 for n.

There is one point which the author's investigation accentuates, that is, the greater importance of the hydraulic mean depth m than of the inclination i. In our own practice we have often had to impress on others that, in open channels, especially in the case of large drains, such, for instance, as those in the Delta of Egypt, where the available fall is very small, increasing the hydraulic mean depth is more effective than increasing the slope in the same proportion, although the popular notion is that greater fall is essential to improvement. There are the cases of the Lower Ganges Canal in India and the Ibrahamia Canal in Egypt, which were materially improved by simply contracting their great width and increasing their depth, thus increasing m, thereby obtaining velocities which now keep the channels clear, notwithstanding their very small surface gradient.

We could never see why, in Kutter's formula, gradient should have been considered an element influencing the coefficient, for whatever may be the total amount of resistance in a length of pipe or channel, it is simply balanced by the ft.-lbs. of work given by the weight of water flowing in that length multiplied by the drop in the same length, so that the slope has no more to do with the factors governing the resistance than the weight in a scale has to do with the ingredients of the article in the opposite scale that it balances. The office of gradient or slope is not to create or accelerate velocity, but is only to maintain a velocity already created or required to be created; and in saying that a particular head or slope gives a certain velocity it would be more correct to say that if a specified velocity is required, a certain slope must be given to maintain that velocity; hence in determining the effective gradient of a pipe it is always the rule to deduct the part of the total head required to produce the velocity of flow. The exponent given to i in a formula is, or ought to be, merely the reciprocal of the power of v to which the frictional resistance is proportional, and comes in the process of getting the value of v from v^2. Also in this connection it is not clear why the factor $2g$ is usually introduced into formulæ for velocities in pipes and channels, for it gives the idea that the gravitation law of falling bodies comes in, whereas that law has nothing to do with the case of steady flow in question. This is why in equation (2) we have purposely used the term $\frac{62.4}{f^1}$, the weight of a cubic foot of water in lbs., and f^1 the resistance in lbs. per square foot of surface with a relative velocity of 1 ft. per second, and not $\frac{64.4}{f}$ being $2g$, and an abstract figure f.

We have devoted so much space to Part I that there is less room than we should have liked for remarks on Part II, which, although dealing with a subject of less general importance, is most interesting as showing the evolution of new formulæ for the measurement of water by triangular notches, weirs and circular orifices. To these Mr. Barnes has adapted the general equation $v = K m^{\alpha} i^{\beta}$ of Part I. by merely substituting the head H for i. Having regard to the concluding portion of our remarks on Part I, it would appear at first sight inconsistent to apply this equation to cases in which the ruling element is the gravitation law of falling bodies, and where frictional resistance plays the minor part of affecting the theoretical velocity to the extent of only about 3 or 4 per cent. But it will be seen that it is merely the form of the general equation that is used, for we are unable to accept the author's claim that there is a direct relation between the flow in pipes and open channels and the flow in notches, orifices and over weirs; however, this point is of no consequence. The object of the adapted formula $v = K m^{\alpha} H^{\beta}$ is to introduce the factor m^{α} into the calculation, which is a new feature, and by means of logarithmic plotting of experimental data to see if such a law as represented by the equation exists, and, if so, to obtain values of the constants K, α, and β, for the different classes of measuring appliances dealt with in Part II, as for the different classes of pipes and channels in Part I. In this Mr. Barnes seems to have been equally successful, though dealing with a distinct set of cases.

To the engineer dealing with weirs on rivers and large running canals, Table VI., page 129, Weirs without End Contractions, is the most interesting, especially the favourable comparison of the calculated with the actual discharges in the Cornell University experiments, where the head, H, on crest reached as much as 6 ft. in a channel 6.53 ft. wide and the height of the crest was only 5.20 above the invert or bed up-stream, showing that good results are obtained when the height of crest above the up-stream bed is about equal to the head on crest. More than this is usually not attainable in practice on large channels. The author purposely omits to discuss the question of drowned weirs owing to doubt regarding the existence of bottom contraction. Our own experience is that when the head on crest reaches 2 ft. and over, and the down-stream water level is not more than $\frac{H}{3}$ above the crest, the force of the cascade scoops out so deep a trough below the weir that there is actually a clear drop over the crest. This action does not affect the velocity due to the depth on crest, as this velocity is independent of how the kinetic energy in the falling water is spent after the water passes the crest.

It will be observed in the velocity equations (which are the ones to study, and not the formulæ giving Q the discharge), viz., that in three out of the four cases the index of m has a *minus* sign, so that $v = K m^{-\alpha} H^{\beta}$ is equivalent to $v = \frac{K}{m^{\alpha}} H^{\beta}$. Hence in these three cases, for the same H, the smaller m is the smaller will be the divisor M^{α}, and the greater will be the velocity, v, which is contrary to what would be expected and to what occurs in the case of pipes and channels. This explains why for a narrow 53 deg. 8 min., nominally 54 deg., V notch with the same H, the velocity works out a little greater than for a 90 deg. V notch just twice the width, although the value of m in the former is 37 per cent. less. The comparison in Table III. on page 110, between Dr. Barr's experimental values with a 54 deg. notch and the values as calculated by the author's formula for a 53 deg. 8 min. notch, would not be quite so close if allowance had been made for the difference of area, which is 1.9, nearly 2 per cent., to be added to the calculated figures.

The matter of importance is that, as in Part I, the figures given by the author's formulæ for V notches, weirs and circular orifices in Part II, are again in remarkably close agreement with observed results under all the varying conditions for which reliable experiments are available. This close agreement in respect of the problems dealt with in both parts is the best testimony to the great practical and scientific value of Mr. Barnes' work.

Bridge Foundations. By William Burnside, Assoc. M. Inst C.E London: Scott, Greenwood and Son, 8, Broadway, Ludgate, E.C. [Price 4s. net.]

This one of the Broadway series of Engineering Hand-Books satisfactorily fulfils the purpose of the author as an introduction to the study of subaqueous foundations for bridge abutments and piers; much of the subject-matter is drawn from the observations and experience of the author in this particular class of work.

The principles affecting the design of subaqueous foundations are outlined and discussed in the introductory chapters. One of the first problems confronting the engineer is the unit load which may be safely placed upon the foundation bed without significant settlement of the superstructure reared upon it. The usual methods of trial pits, bores, and testing of the subsoils are described, and the principal points to be taken into consideration in deciding on its bearing capacity are explained. Examples from actual practice are given of the forces acting on a foundation from the dead weight of the superstructure and pier, and from occasional loads, such as the moving loads carried by the bridge, the application of brakes to a rapidly-moving live load, wind pressure, water pressure, and temperature.

The stability of a pier foundation is dependent upon its dead weight, the bearing capacity of the soil, the friction of the embedded surface of the pier, and the buoyancy of the pier if founded upon a pervious material. As a general guide in making preliminary studies, information as to the loads on existing foundations, and values for skin-friction from experiments conducted during sinking operations are collected, and given in tabular form.

The author describes at some length the various methods of using bearing piles, sheeting piles, and screw piles in foundation work, and gives many examples of practice derived from existing works.

The practice of making foundations by means of brick wells, which has been in use in India, Egypt, and Burma for centuries, and its modern application for bridges in India and Egypt are also referred to at some length, special points being illustrated by examples which came under the notice of the author.

The foundations already referred to form the majority of cases occurring in an engineer's daily practice. In important structures the foundations are generally carried out by either the pneumatic process or by excavating in open caissons; and as the author has had considerable experience in the latter class of work, a large portion of the book is devoted to caisson foundations.

Stranded caissons, so called from being made box-shaped and sunk or lowered on to a prepared bed, were adopted in the case of the piers of Old Westminster Bridge, constructed in 1738, and were popular with engineers in this country in the eighteenth and early part of the nineteenth centuries, but have generally been abandoned in favour of pneumatic or open caissons. Their use is now practically confined to the Continent and America, and some recent examples are described. Pneumatic and open-topped caissons for grab-dredging have been extensively used in all countries for bridge and other foundations. In America timber is commonly used in constructing the caissons on account of its cheapness, but elsewhere steel is now practically the only material adopted.

Practical points in the design of the caissons and in their manipulation during sinking operations are described and emphasised. A chapter is devoted to the effects of compressed air on the workmen engaged in the sinking operations, and recent experiences and authoritative recommendations have been summarised. The concluding chapter is devoted to various types of foundations which do not come under the general headings in the book, and some useful tables for reference are added.

Navigation Notes and Examples. By Naval Instructor S. F. Card, B.A., R.N., Head of the Navigation Department and Lecturer in Navigation at the Royal Naval College, Greenwich. London: Edward Arnold. [Price 8s. 6d. net.]

If this work were put forward as a treatise on navigation it would be distinctly disappointing, especially considering the high authority from whom it emanates. As "Navigation Notes," however, it is rather to be regarded as an *aide-mmoire*, as collection of rules and directions, with which the student who has read the subject, but does not wish to burden his memory or to deduce formulæ from first principles, may extract the precise piece of information needed.

But the book is really something more than this, for it does give proofs of some propositions, and it is in this apparent effort to combine elementary teaching with precept that the result ceases to be satisfactory. We should be sorry to think that our navigating officers are trained on the plan indicated here, for it does not make for thoroughness, for accuracy, or for self-reliance. Rightly or wrongly, the impression given is that the tutors who would use such a text-book are not so anxious to teach navigation as to teach the method of using tables sanctioned by long usage, in which ingenuity and careful arrangement supply the solution of certain simple problems with a minimum of trouble.

Such a practice is not one that can be recommended: the case is eminently one in which the advantages to be derived from the preparation of a sound mathematical basis should not be neglected. For this reason we are not disposed to look too favourably on the opening chapters on spherical trigonometry, in which the author apparently satisfies himself by deriving the expression for the cosine of a side of a triangle. This is but a snippet of the more general treatment, in which, by a simple transformation of co-ordinates, the three principal formulæ of spherical trigonometry can be derived. Further, in some of the examples, difficulties that are encountered by working with the cosines of small angles would have been avoided if a more generous course in spherical trigonometry had permitted the use of a formula involving the tangent of the angle. If, too, Mr. Card had instructed his pupils to differentiate the formulæ of spherical trigonometry, he would have found his work simplified and made more

thorough when he came to treat of some problems connected with change of altitude, and the choice of suitable objects for observation.

In the parts dealing with the more technical side of the subject, we submit that it is unwise to rely upon a purely mechanical use of the tables of the Nautical Almanac. Facility in the manipulation of tables is but a poor substitute for a thorough knowledge of method. It would have been better to have given an intelligent insight into the mode of calculating ephemerides, and the general principles of interpolation. Such knowledge would not only have tended to promote a uniform standard of accuracy, but it would have prevented some expressions which, if not erroneous, may at least be misleading. What, for example, is the object of the author in stating that the mean sun is nearly coincident with the true sun at the first point of Aries, when a footnote states that there is about 7½ minutes' difference in time of transit, a quantity rather greater than the average (p. 80)? Or that the maximum parallax of the planets is about 30″ (p. 102)? Or, again, why is there no mention of Moon's parallax in determining the time of rising and setting; or of the apparent places of the stars in preference to the mean places? Possibly because the author was writing rather a guide to the use of Inman's and similar Tables, rather than to those of the Nautical Almanac. On the other hand, he provides an unusually large number of examples, and this is a feature common to most works on nautical astronomy. Frequent practice in particular instances is thought a desirable substitute for familiarity with general principles.

BOOKS RECEIVED.

United States Coast and Geodetic Survey. Special Publications. No. 27: *Latitude Observations with Photographic Zenith Tube at Gaithersburg, Md.* By Frank E. Ross, Ph.D. No. 29: *Wire Drag Work on the Atlantic Coast.* By N. H. Heck and J. H. Hawley. No. 30: *Triangulation in West Virginia, Ohio, Kentucky, Indiania, Illinois and Missouri.* By A. L. Baldwin. No. 31: *Triangulation along the Columbia River and the Coasts of Oregon and Northern California.* By Charles A. Mourhess. Washington: Government Printing Office.

The Principles of Apprentice Training, with Special Reference to the Engineering Industry. By A. P. M. Fleming and J. G. Pearce. London: Longmans, Green and Co. [Price 3*s.* 6*d.* net.]

French and English Commercial Correspondence. By William Chevob-Maurice and C. Laroche. London: E. Marlborough and Co. [Price, in wrapper, 1*s.* net; in cloth, 1*s.* 6*d.* net.]

A Manual of Practical Physics. By H. E. Hadley. London: Macmillan and Co., Limited. [Price 3*s.*]

Factory and Workshops Acts, 1901 to 1911. Memorandum by the Electrical Inspector of Factories on the Electricity Regulations. Second Edition. London: H.M. Stationery Office and Wyman and Sons, Limited; Edinburgh: H.M. Stationery Office; Dublin: E. Ponsonby, Limited; or from British Colonial and Foreign Agencies of T. Fisher Unwin, Limited. [Price 4*d.*]

Canada Department of Mines. Annual Report of the Mineral Production of Canada, 1914. By John McLeish, B.A. Ottawa: Government Printing Bureau.

Western Australia Geological Survey. Bulletin No. 64. *Miscellaneous Reports, Series IV., Nos. 52–60.* Perth: F. W. Simpson, Government Printer.

United States Department of Labour, Bureau of Labour Statistics. Bulletin Whole Number 191. *Collective Bargaining in the Anthracite Coal Industry.* Washington: Government Printing Office.

United States Department of the Interior. Bureau of Mines. Fifth Annual Report by the Director of the Bureau of Mines to the Secretary of the Interior, 1915. Washington: Government Printing Office.

United States Department of the Interior. Bureau of Mines. Bulletins: No. 104. Mineral Technology 12. *Extraction and Recovery of Radium, Uranium and Vanadium from Carnotite.* By C. L. Parsons, R. B. Moore, S. C. Lind and O. C. Schaefer. No. 113. Law Serial 6. *Abstracts of Current Decisions on Mines and Mining, May to December, 1915.* By J. W. Thompson. Washington: Government Printing Office.

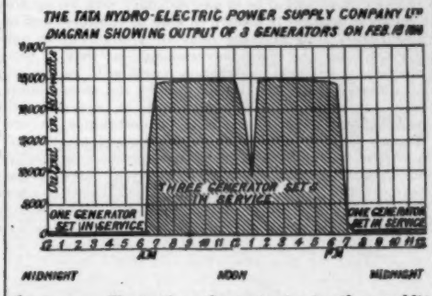
British Prisoners of War.—Friends and correspondents of our interned men, when writing to them, should acquaint them with the existence of an Educational Book Scheme under which they can get their wants supplied. Under this scheme any such prisoner can obtain, free of charge and carriage paid, good books of an educational character (not fiction or light literature) on almost any subject for reading or private study during his internment by communicating (either directly or through a correspondent) with Mr. A. T. Davies, of the Board of Education, Whitehall, London, S.W. Prisoners are invited to state as precisely as possible on a form (which can be had gratis on application) what kind of books they desire.

THE TATA HYDRO-ELECTRIC POWER SCHEME, BOMBAY.

The Tata hydro-electric power scheme was described fully in our issues of October 24 and 31, 1913. The accompanying diagram has just reached us and illustrates the output after less than 12 months from the date of the first supply. There is, we believe, no instance on record where the load on any central supply station has approached in magnitude, in such a short time, the load of this station.

This load is practically a cotton-mill load, and the above output is taken by only 33 consumers, the maximum individual consumer taking 2,375 h.p. and being equipped for 2,400 h.p., and the minimum for 225 h.p. And it may be remarked that a load approximating to the above in Rio has no less than 32,000 customers.

When the station is completed the output will be about 80,000 kw. for approximately 60 consumers. The load curve reveals the fact that from 6 in the morning until 6 in the evening the output is exceptionally steady, and if this load curve is compared with


THE TATA HYDRO-ELECTRIC POWER SUPPLY COMPANY LTD
DIAGRAM SHOWING OUTPUT OF 3 GENERATORS ON FEB 18 1916
THREE GENERATOR SETS IN SERVICE
ONE GENERATOR SET IN SERVICE
ONE GENERATOR SET IN SERVICE
MIDNIGHT
NOON
MIDNIGHT

the curves illustrating the output at other public supply stations throughout the world between those hours, it will be seen how very much more satisfactory it is than the others.

If the company succeeds in developing the night load to any appreciable extent—and there is reasonable hope of it doing so—then the general load factor will undoubtedly be one of the best in the world.

The chief reason for the result obtained is the extraordinarily steady load on the mills. This steadiness has far exceeded the expectation of Messrs. Alfred Dickinson and Co., of Birmingham, the engineers, and they consider that no such satisfactory result can be obtained from any other character of load. Apart from the interest in the load curve, the electric supply to the cotton mills of Bombay has been eminently pleasing from the point of view of textile output. This output has been substantially increased without increasing power costs beyond the original power cost of the old steam-driven plant. Prior to the introduction of the electric drive, pessimists publicly stated that a charge of 0.55 of a penny per unit for electric energy (which charge includes free installation and maintenance of all electric motors) would result in the power costs in the mills exceeding those of the steam-driven plant. But in addition to an increased textile output at no increased charge, the quality of the yarn spun has materially improved by the steadier drive.

Agricultural Machinery.—Our agricultural machinery has suffered as much from the war as almost any other branch of the national industries, the value of the exports in June having declined to 13,432*l.*, as compared with 16,852*l.* in June, 1915, and 154,729*l.* in June, 1914. In the six months ended June 30 the exports were valued at 85,537*l.*, as compared with 103,443*l.* and 856,899*l.* The largest shipments made to any one country to June 30 this year were those to British India, which were valued at 20,135*l.*, as compared with 30,514*l.* and 49,525*l.* respectively.

Proposed Steam Ferry Connection between England and Sweden.—The Swedish Government has taken up the question of the establishment of a daily steam-ferry connection between that country and England. The project was considered in 1913, but was dropped. The Department for Commerce is of opinion that a sufficient quantity of goods can be secured to make the undertaking pay its way, while a considerable transit traffic between England and Russia may be anticipated. The control of the undertaking would be left in the hands of the State railways and, pending the construction of steam ferries, a steamer service arranged for. The Swedish port to be chosen for the new traffic will no doubt be Gothenburg; Kristiansand or another suitable port in Southern Norway would serve as an intermediate port, from which the ship will go straight across the North Sea, in all probability to Immingham. A railway will no doubt have to be constructed from Stockholm to Kopellakör or other suitable point on the coast, whence connection will then have to be established with the Finnish or Estland coast.

GERMAN RAILWAYS IN THE FIRST YEAR OF THE WAR.

The official report of the German railways for the financial year ended March 31, 1915, has just been issued. This year includes the first eight months of the war, and, as might be expected, the profits have fallen off, as shown by the annexed table. Under all heads the receipts have diminished, the only item of increase being in the total expenses, which have risen, both relatively and absolutely, from 2,490,400,000 marks to 2,513,200,000 marks. For the year they stand at 80.19 per cent. of the total receipts, against 70.03 per cent. in the previous year. But working expenses have a tendency to increase on German railways, as elsewhere, and in the previous five years were 70.6, 67.96, 65.81, 67.47 and 70.3 per cent.

German Railway Accounts.

	1913-14.	1914-15.	Increase or Decrease.
	Marks.	Marks.	Marks.
Profit	1,065,700,000	621,020,000	– 444,680,000
Percentage ...	5.70	3.20	—
Passenger & luggage receipts, &c.	1,017,500,000	837,300,000	– 180,200,000
Passenger receipts	967,000,000	736,300,000	– 230,700,000
Military passenger receipts	17,800,000	70,000,000	+ 62,200,000
Luggage receipts	30,000,000	23,600,000	– 6,400,000
Goods receipts ...	2,386,300,000	2,041,800,000	– 344,400,000
Percentage of total	64.16	65.02	—
Total receipts ...	3,556,100,000	3,134,300,000	– 421,900,000
Expenses	2,490,400,000	2,513,200,000	+ 822,800,000
Percentage of receipts	70.03	80.19	—
		Miles.	
Length of line ...		39,143	
German State Railways		36,315	
Private railways...		2,206	
Prussian Hessian railways		24,591	

It is a matter of surprise to find that the receipts for military passenger traffic were only 70,000,000 marks, when we remember the great transferences of troops from West to East to meet the Russian incursion into East Prussia and elsewhere. Moreover, in the previous year, in a time of peace, the receipts under this head were nearly 18,000,000 marks. Thus an increase in the size of the army of seven to ninefold, and an enormous increase of its activity, have only multiplied the cost of moving it fourfold. Evidently new war rates have been established on a very low scale.

The capital laid out by the present owners of the railways amounts to nearly one thousand millions sterling (19,835,300,000 marks), of which 19,464,400,000 marks are debited to the State Railways and 370,900,000 marks to the private railways. These work out respectively to 25,000*l.* per mile and 8,400*l.* per mile. The total length of the German State Railways opene for traffic at the end of the year in question was 36,315 miles, and that of the private railways 2,206 miles. The Prussian-Hessian State Railways comprise 24,591 miles. Of the German State Railways 22,000 miles were worked as main lines, while 23,000 miles were single lines, 15,000 miles double lines, 45 miles triple lines, and 250 miles quadruple lines.

At the end of the financial year the rolling stock comprised 30,633 locomotives, an increase of more than 1,100; 20,067 tenders, 67,491 passenger carriages, and 719,555 goods wagons and luggage vans. The aggregate outlay for the stock is put at 251,570,000*l.* The cost of construction of the railways is taken as 1,010,350,000*l.*, or 26,100*l.* per mile.

The receipts from passengers and luggage amount to 26.66 per cent. of the total, while those from goods are 65.02 per cent. These figures work out to 1,100*l.* per mile for the former and 2,540*l.* for the latter. The total receipts were 4,050*l.* per mile worked. The working expenses were 3,250*l.* per mile worked, or 6*l.* 18*s.* per 1,000 axle-miles.

The number of officials and men employed by the ordinary gauge railways during 1913–14 amounted to 764,028 persons, against 786,466 persons for the previous year, or about 20 per mile. In salaries, wages, &c., were paid 1,394,600,000 marks, against 1,351,400,000 marks for the preceding year, which comes out at respectively 1,800*l.* and 1,780*l.* per mile worked.

The Panama Canal.—The first use of the new 1,000-ft. dry dock at Balboa, says the *Canal Record*, was made with the docking of the ladder dredge Corozal on June 27. The vessel was brought at high tide through the gap in the earth cofferdam which had protected the dry dock and its approach basin during construction, and moored in the dock in the afternoon of that day, but the pumping out of the dry dock did not begin until the morning of June 28. The docking of the Corozal is an emergency measure, as she has been leaking at several points in the hull and is in need of some renewed plates and new rivets. The new dry dock at Balboa will be able to accommodate any ship now afloat when the removal of the cofferdam across the entrance is completed.

THE BRITISH MANUFACTURER AND CHAMBERS OF COMMERCE.

In our issue of July 21, page 67, under the title of "Trade War in China," we published a series of notes we had received from a correspondent who had just returned to this country from abroad. He has now sent us a further record of his impressions gathered in foreign countries, and these cannot fail to be of interest to our readers.

The paradoxical method of the British manufacturer is one of the first things that strikes the average business man when travelling abroad. The manufacturer concentrates his whole energy in producing an efficient and substantial article, he employs the best brains he can procure for the heads of his departments, obtains the most up-to-date machinery, does everything that brains, energy and money can do to turn out an article that will be the best of its kind on the market; and there he seems to stop. It may be called creative genius, but it is not business. Advertising in the British technical Press will produce a large amount of inquiries, but there are customers abroad who have not the opportunity to read these advertisements and who wish to see the class of machinery before purchasing. The manufacturer replies, "But I have appointed agents there, who carry a certain amount of my goods." That constitutes the paradoxical method of the British manufacturer; he makes certain that his manufacturing end is efficient, but he is almost indifferent to the selling end. Few of the smaller manufacturers have personal knowledge of their agents abroad. They are altogether unacquainted with their methods and place of business, the similar class of foreign goods, with perhaps better commission, they may be selling, and, what is, and will be, more important, the nationality of their assistants. In a large importers' business the work is necessarily done by assistants, and in countries like Argentine and Brazil many of the selling assistants are Germans appointed for their linguistic capabilities. About two years before the outbreak of the present war the writer visited the Argentine on business, in furtherance of a wish expressed by the Minister of Agriculture, who had just opened a new oil well; he called on the different importers of oil engines, and the following is an instance of how the assistant in one of the two largest machinery-importing houses, who was a German, pushed (?) the sale of British goods. On entering the oil-engine department the writer was shown a special cooled engine of German manufacture—"Special workmanship; designed for work up-country, &c." In view of the scarcity of water in the "camp," under ordinary circumstances, the cooling arrangement would have been a point of merit. After stating that the engine was not suitable, the writer was shown an American engine of a much cheaper class; he informed the assistant that what he wished to see was a British engine of substantial build. He was taken to the other side of the show-room, where he was shown the product of a well-known British engineering firm. That is one instance of many the writer came across in South America where British goods were not shown until asked for. This firm of importers are British, and no doubt would have dismissed the assistant if it had come to their knowledge that he was showing German and American engines before British. The average small manufacturer cannot spare the time, &c., to visit the different houses handling his goods, and no doubt has considered in the past that the nationality of their assistants did not come under his cognizance; in many instances he was unaware of the business integrity of his agent.

What is necessary is a British Chamber of Commerce run on the same scale as our Consular service—in fact, conjointly with it. There are being opened up labour exchanges specially for the demobilising of the troops, but more important, first, we must secure the commerce to support the workshop, and to do that we must keep up our exports. The manufacturer at home is on many occasions unaware of the best market for his particular class of goods; he often requires to know what kind of machinery there is a demand for in a certain part of the world. There may be some small detail which if altered would create a demand for his machinery in that part; he may wish to send literature or an exhibition machine out before settling on an agent. If his agent is not pushing his particular article, or is dealing in enemy goods to the detriment of the British article, he requires someone on the spot to consult, also to see that no anti-British assistants are employed by his agent. These are some of the things that would be undertaken for him by the Chamber of Commerce. There are being formed abroad at the present time local British (?) Chambers of Commerce; they are a delusion, and the British manufacturer at home can expect no benefit from them. They are run solely for the benefit of a few local influential merchants, on whose contributions they are supported, either through advertising in their journal, or otherwise. The writer has not penned these words without due consideration and sufficient evidence to support them. The secretary of a large British (?) Chamber of Commerce abroad wrote an article at the request of the committee which, although in the interest of British trade in general, was slightly to the detriment of a few members. The article on their recommendation was condemned to the waste-paper basket.

When one speaks of a British Chamber of Commerce, he cannot mean an organisation that is run solely for the benefit of a few local merchants, who pay a few shillings a year to be registered as British subjects, their only contribution to the upkeep of the British Empire. He means an organisation that is solely to promote British trade, to assist the British manufacturer and through him his employees, the men who pay for the support of the Government. The chamber would require to be given special powers to protect British trade abroad. One of the advantages of the world-wide British Chamber of Commerce would be that it could be depended on as a reliable source of information for the British manufacturer and a department that he could appeal to in any difficulty with his agents or export trade. It should be able to subsidise native newspapers (this is being done to a large extent out East by the Japanese Government), so that a firm British only could arrange a world-wide campaign of advertising through a central office and at minimum cost. It should have power to loan, on good security, Government money for large undertakings, where British plants or machinery would be supplied. Within the past few months there have been some very large German loans put through in different parts of the world. The British (Samuel and Co.) loan for 3,000,000*l.* with the Hankow Electric and Water Supply as security fell through, but was taken up by the German financiers, and will no doubt have a very large effect in promoting German trade there. The Chamber would require to be run with less red tape and by men with practical experience. If copied from the usual Government department, it would be useless, but it has yet to be formed, and it is for the manufacturers to arrange that it will be run in their interest and set in motion before the conclusion of hostilities, so that they may have every facility to arrange their campaign, class and design of goods, suitable agents, &c., to secure that there will be no lull between the last order for munitions and the manufacture for export. Our engineering workshops must be kept in readiness for munition work, if not for our own requirements, in the near future, perhaps for our Allies, and they must in future be as much a charge of the Government as our Navy or our Army. It is for the Government to exert themselves to assist the manufacturer to make his business a profitable concern, which he can do through increased output, resulting from turning the work into repetition work, by encouraging certain firms to confine their activities to certain branches (as they are doing at present with munition work) and so do away with needless competition; by assisting manufacturers, in their experiments, to enter into competition in certain classes of machinery that at present is not being manufactured here, and thus aid them in keeping their works in the highest state of efficiency for a sudden emergency call, to protect not only the commerce but the life of the Empire. We must in future be the leading machinery manufacturers, so that we may have trained men and efficient workshops, just as we must retain supremacy at sea. The Government will require to consider, at once, the best methods to promote this end.

"The Munitions of Peace: Our Preparations for the Trade War."—This is the title of a brochure by Mr. H. E. Morgan, published by Messrs. Nisbet and Co., Limited, 22, Berners-street, London, W., and, as its sub-title shows, is a call to the nation to organise itself for trade after the war. The author, having established the need for preparation and shown how in the past neglect, notably in agricultural industries, has involved very heavy imports, particularly of eggs, fresh fruit, sugar, &c., proceeds to establish the importance of conserving our supplies of raw material. He then considers, in separate chapters, as factors in production, the workers, the employers, and the Government. The author wields a pretty vigorous pen, and pushes home truths to the point of conviction. He covers the whole field, but there is not much that can be termed original in his suggestions for the improvement of the situation. One of his panaceas is a national trade agency, and its functions are suggested by the sub-headings of this chapter—collection of trade information, national publicity, exhibitions, imperial relations, migration within the Empire, trade relations with other countries, financial encouragement of industry, problems of transportation, business education, development of inventions, scientific research in relation to industry, and advice on wages problems. This is a great programme. While some of the work ought to be done by Government agency, some must be undertaken by organisation of trades and the individual enterprise of separate firms. The danger of the advocacy of collective effort is that some firms may be disposed to relax that personal effort which, after all, is most effective in developing business.

BOARD OF TRADE IRON AND STEEL INDUSTRIES COMMITTEE.

We have been officially asked to state that the Departmental Committee on the Iron, Steel, and Engineering Industries has now been reconstituted, and a separate Committee has been appointed by the Board of Trade to consider the position after the war of the iron and steel industries. This Committee comprises: Mr. G. Scoby Smith, Chairman; Sir Hugh Bell, Bart., Mr. Archibald Colville, Mr. John Hodge, M.P., Mr. James Gavin, Mr. George Mure Ritchie, Mr. Henry Summers, Mr. Benjamin Talbot, Mr. John King and Mr. John E. Davison. It was appointed "to consider the position of the iron and steel industries after the war, especially in relation to international competition, and to report what measures, if any, are necessary or desirable in order to safeguard that position."

In order to carry out its investigations, the Committee desires to elicit exact and detailed information from a number of representative and individual firms, and from industrial, commercial, and labour organisations, with respect to:—(1) The extent and area of trade, and capital normally employed. (2) The dependency upon resources external to this country for supplies of material and plant. (3) Labour relations, labour restrictions (if any), and comparative conditions in the industry. (4) British methods of conducting foreign business contrasted with foreign methods of conducting export business. (5) The effects of manufacturing and commercial co-operation upon trade at home and abroad. (6) The extent to which British industry is adversely affected, whether as regards (*a*) the retention of business hitherto or previously secured, or (*b*) its capacity for expansion, by the existence of foreign tariffs, preferential arrangements, bounties, subsidies, or special facilities granted by foreign governments, railways, or trade combinations, to their manufacturers or exporters; and what, in your opinion, is the remedy. (7) Terms of payment and of credit. (8) Technical education, skill, and nature of employees. (9) The effect, if any, of wayleaves, and mining or other royalties upon the industry, either as regards home or export trade. (10) The effect, if any, of railway and shipping rates upon the industry, as regards home or export trade. (11) General information.

The recommendations of the Committee must depend for their effectiveness upon the co-operation of all who are interested in the British iron and steel industries. The Committee, therefore, invites the active support and assistance not only of individuals, but also of industrial organisations of whatever character. The Committee suggests that the various trade organisations should submit, either through their secretaries or through small committees, a general statement of their views together with suggestions which, in their opinion, might desirably form the foundation of practical measures in the future. The general evidence might suitably be supported by the presence of a deputation representative of the organisation as a whole. The Committee will be glad to receive statements supported by verbal evidence from representative firms, and from individuals, whose depositions, in the opinion of the Committee, will be valuable to their work. It will also welcome the assistance of import and export merchants who are interested in the handling of the products of the iron and steel industries at home and abroad. The Secretary is Mr. C. Roland Woods, 6, Whitehall-gardens, S.W.

THE AIR RESISTANCE OF FLYWHEELS.

To the Editor of Engineering.

Sir,—I shall be pleased to be informed by some of your readers what is the power saved by lagging the flywheel of an engine, 14 ft. in diameter, running 100 revolutions per minute.

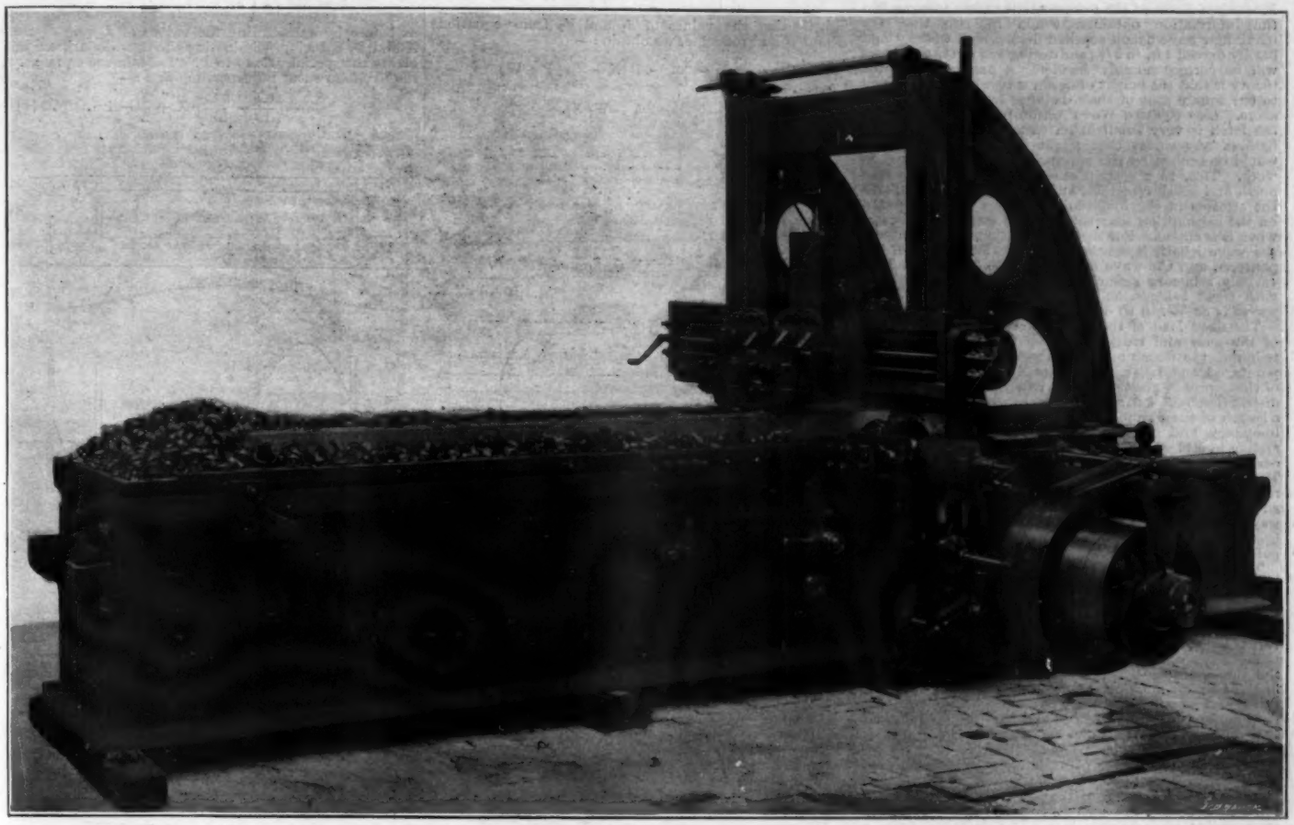
August 7, 1916. Interested.

English-French Commercial Correspondence.—Messrs. E. Marlborough and Co., 51, Old Bailey, E.C., issue at the price of 1*s.* wrapper, and 1*s.* 6*d.* cloth bound, a book of English and French commercial correspondence, by Mr. W. Chevob-Maurice and Mr. C. Laroche. The examples of letters given deal with a very large variety of commercial, shipping and banking cases, and should greatly facilitate matters both to young Frenchmen learning commercial English and young Englishmen learning commercial French.

Exports to the United States of America.—We have received the following announcement from the Board of Trade:—"The attention of the Board of Trade has been called by the Foreign Office to cases which have occurred in which British firms have consigned to one of His Majesty's Consular officers in the United States of America an account of certain United States approved importers' materials in connection with which the importers are required to sign (and in the case of any previous shipments received have signed) guarantees before a British Consular officer to the effect that they will take certain precautions to prevent the materials from reaching the enemy. On arrival of the particular shipments in question, however, the importers have in certain cases refused to sign the requisite guarantees in respect of them, and the British exporters have been compelled to store the goods with little prospect of selling them to other importers prepared to sign the guarantees. The Board of Trade desire to suggest that, with a view to obviating such difficulties, exporters of such materials should include in their contracts with United States importers a condition that the necessary guarantees will not be withheld in the case of any of the goods covered by the contracts."

HIGH-SPEED PLANING MACHINE.

CONSTRUCTED BY MESSRS. C. REDMAN AND SONS, ENGINEERS, HALIFAX.



WE illustrate in the view on the present page a 3-ft. high-speed planing machine of new design, built by Messrs. C. Redman and Sons, Halifax, to plane 8 ft. long, 3 ft. wide and 3 ft. high. The bed is 12 ft. in length and 24 in. in depth. The vees are 20 in. between centres and are extra wide on their bearing surfaces. The table has a length of 9 ft. and a width of 32 in. All the gears are placed inside the bed, and all the feed motions for horizontal, vertical and angular cuts are reversible and variable without stopping the machine. The lifting motion is within easy reach of the operator, and ball bearings are provided under the bevel wheels which lift the cross-slide. All the gears and racks are of steel, machine-cut from the solid and made specially wide. The small pinions of the mitre wheels in the tool boxes are of mild steel, also machine-cut. All the shafts, where required, are ground on centres and run in reamed holes, and all slides are carefully scraped to fit. The top edge of the cross-slide is square, and the saddle is provided with double solid abutment take-up strips. The belt-shifting gear is of steel throughout. All the bearings in the bed are bushed. The rack movement is by a large wheel geared into the rack and keyed on a shaft which has no torsion strain upon it. The countershaft has fast and loose pulleys, 12 in. in diameter for a 6-in. belt, and when run at 332 r.p.m. the cutting speed of the machine is 30 ft. per minute and the return speed 120 ft. per minute. Our illustration shows the machine planing mild-steel slabs with two tools cutting at one time, each tool taking a cut $\frac{1}{8}$ in. deep, 18 cuts per inch at a 47-ft. per minute speed. The chippings shown on the top of the machine represent this cut.

INDIAN IRRIGATION.—The Government of India has invited attention to recommendations contained in a report of the Irrigation Commission with regard to the saving of water in the irrigation of crops. The Government desires that a special inquiry should be instituted into the methods of paddy cultivation as practised in the deltas of the Godavery. The western delta is selected as the most suitable area for conducting such an inquiry. The tract chosen for special observation is the Attili Canal area, which has an extent of about 45,000 acres.

DESIGN OF A RAILWAY PONTOON BRIDGE.*

By H. J. HANSEN, M.W.S.E.

(*Concluded from page* 116.)

THE stresses in a pontoon affecting the structure as a whole are produced by unbalanced weight and buoyancy forces. These stresses are transmitted to and carried in the main longitudinal and transverse trusses. In addition to these stresses the various members may be subject to local stresses caused by concentrated loads on the structure. The local stresses are obtained by the ordinary methods employed for stationary structures, and there is nothing new in the theory leading to the main stresses as outlined in the following :—

A body resting in still water displaces a volume of water equal to its own weight, and its centre of gravity lies in the same vertical line as the centre of gravity of the water it displaces. This is the condition for equilibrium of any floating body.

When the body is of uniform density and shape, it will experience no stresses, save the compression due to its own weight and the water pressure on its sides. If, however, a concentrated load is placed on the body, then the weight and buoyancy forces no longer balance at every point, and shearing and bending stresses are set up which must be resisted by the body.

The buoyancy force per foot of length of a vessel is equal to the volume of water displaced, between two transverse vertical planes, distant 1 ft. apart, multiplied by the weight of water. If, on a base line representing the length of the vessel, we plot this buoyancy force per foot of length below the base line and the weight per foot of length of the structure to the same scale above the base line, we will have a graphical representation of the forces acting on the structure in a vertical direction. The area between the upper curve and the base line is equal to the area between the lower curve and the base line, and the centres of gravity of the two areas lie on the same vertical straight line. By adding the ordinates of the two curves and plotting the differences we obtain a new curve, called the load curve, having ordinates proportional to the forces producing stress in the structure.

As an illustration, the buoyancy and weight curves for a rectangular scow loaded at the centre are shown in Fig. 48b. The condition of loading and the displacement is shown in Fig. 48a. The load, moment and shear curve are shown in Fig. 48c. The condition of loading is as follows :—

Dimensions of scow, 40 ft. by 10 ft. by 5 ft.

Weight of scow uniformly distributed, 20,000 lb.

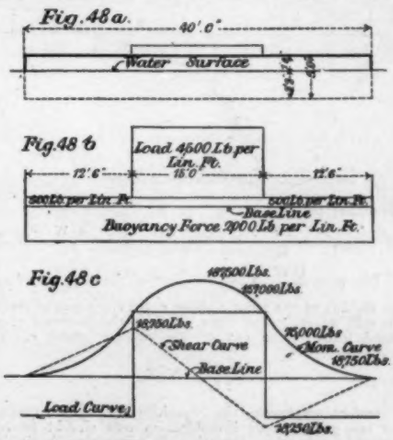
Uniform load of 4,500 lb. per linear foot for 15 ft. at centre. The total load then is 80,000 lb.

The buoyancy per foot of length is $\frac{80,000}{40} = 2,000$ lb.

Weight of scow per lineal foot of length $= \frac{20,000}{40} = 500$ lb.

Weight per foot of centre loaded portion = 4,500 lb.

In case of rough weather and uneven water surface, the stresses will generally be increased as when a vessel is carried on the crest of a wave, Fig. 49, or astride two consecutive waves, as in Fig. 50. The construction of the load curve is essentially the same as for the simple case where the vessel is resting in still water. The weight



* Paper read before the Western Society of Engineers, U.S.A.

curve remains unaltered, but the buoyancy curve, of course, changes and with it the load curve. It is seen that while the forces acting upon a vessel resting in still water can be accurately determined, the conditions when the water surface is uneven are somewhat different; it being necessary in this case to base our calculations on assumptions covering the most severe conditions.

Our information relative to formation of waves in the Mississippi River at the bridge site is rather meagre, but the information obtained would indicate that the maximum wave height reached during high water would hardly exceed 1 ft. to 2 ft., and during low water the waves will be correspondingly smaller. A generally adopted theory is that the height of ocean waves are proportional to the square root of their distance from the windward shore. (See Gaillard Wave Action.) At the bridge site the fetch is very small in an east and west direction; besides, any waves that might form in this direction would be broken by the approach trestle and protection work. This, to a certain extent, is also the case in a north and south direction, and in view of this condition the stresses in the longitudinal trusses were computed on the assumption that the pontoon rests in still water when it is closed. For the open position of the pontoon, the wave length is assumed equal to the length of the pontoon, and the wave height equal to 2 ft. This is an entirely arbitrary assumption, based on our experience with these bridges, as ordinarily the height of ocean waves is one-tenth to one-twentieth of the wave length.

The dead load of the pontoon consists of the weight of the scow and trusses assumed to be uniformly distributed, the floor uniformly distributed between panel points L3 and L3 (Fig. 13, Plate XI. *ante*), the reaction of the approach girder spans at panel points L3 assumed distributed over 4 ft., and the machinery distributed over a length of three panels at each end of the pontoon. The buoyancy and weight curves for dead-load pontoon resting in still water are shown in Fig. 51*a*, and the load curve, moment and shear diagrams are shown in Fig. 51*b*. The corresponding dead-load diagrams for the pontoon resting on a wave crest are shown in Fig. 52 (*a* and *b*), and for the pontoon supported astride two consecutive waves in Fig. 53 (*a* and *b*). The live-load stresses are best obtained by laying out the influence line for the point under investigation.

The equation of the influence line for both moment and shear for a rectangular scow can be reduced to the general form $M = PX + q$, in which M and X are the variables and in which the equation therefore represents a straight line which can be plotted by giving two special values to X.

The influence lines to a certain extent depend upon the shape of the scow, and as the pontoon sides are inclined at an angle of 45 deg., the influence lines for this structure will not exactly coincide with the influence lines derived for a scow of rectangular cross section, and the derivation of the influence line equation becomes much more complicated, due to the fact that for an eccentric load the water plane intersecting the pontoon is no longer a rectangle, but a trapezoidal figure that varies with the position of the load, thus introducing a third variable into the equation, which is then no longer an equation of a straight line. The deviation from a straight line, however, is not very great, it being mainly due to the difference between the moment of inertia of a trapezoid and a rectangle, determined by the intersection of the water surface with the pontoon. This difference may be reduced to a negligible quantity by choosing a suitable width of the pontoon and treating it as a scow of rectangular cross section. For the pontoon in question it was found that by considering it as a rectangular cross section of width *b*, as shown in Fig. 54, the total error due to this arbitrary assumption would in no case exceed one-tenth of 1 per cent. In developing the equations of the influence lines it is assumed that the centre of gravity of the dead loads coincides with the centre of the pontoon.

Fig. 55 shows the distribution of dead load over the pontoon, and the various positions of the live load having different effect in producing moment and shear are shown in Fig. 55 (*a*, *b* and *c*). The notation is as follows:—

- P = concentrated live load.
- P_1 = concentrated load at panel points.
- W = total dead load on bridge.
- W_1 = total dead load to left of *c*.
- R = P + W = total dead and live load.
- L = length of pontoon.
- *b* = assumed width.
- A = *b*L = area of the assumed bottom of the pontoon.
- λ = distance from left end to point under investigation.
- *x* = distance right or left from centre of pontoon to P.
- x_1 = distance to *c* from centre of gravity of all dead-load forces to the left of *c*.
- $e = \frac{P X}{R}$ = eccentricity.
- $I = \frac{b L^3}{12}$ = moment of inertia.
- *c* = any point under investigation.
- d_1 = draught at left end.
- d_2 = draught at right end.

When R falls inside the middle third, and assuming the weight of water at 62.5 lb. per cubic foot, we have:—

$$d_1 = \left(\frac{R\, e \frac{L}{2}}{I} + \frac{R}{A} \right) \frac{1}{62.5} \quad . \quad . \quad (A)$$

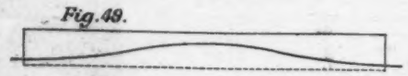
$$d_2 = \left(- \frac{R\, e \frac{L}{2}}{I} + \frac{R}{A} \right) \frac{1}{62.5} \quad . \quad (B)$$

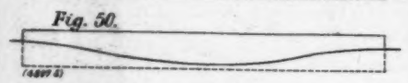
The moment at *c* when P is to the left of *c* (Fig. 55*a*)

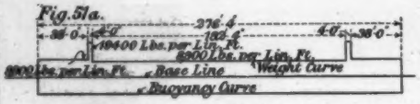
$$M c = \frac{62.5\, \lambda^2 b}{2} \left[d_1 - (d_1 - d_2) \frac{\lambda}{L} \right] + \frac{2 \times 62.5\, \lambda^2 b}{3 \times 2 \times L} (d_1 - d_2) - P \left[X - \left(\frac{L}{2} - \lambda \right) \right] - W_1 X_1.$$

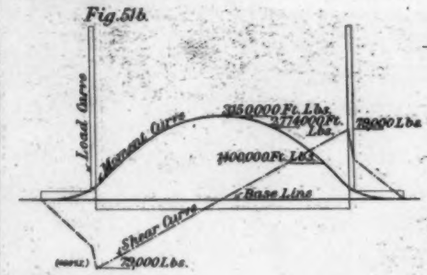
Substituting the values of d_1 and d_2 from equations A and B and reducing, we obtain:—

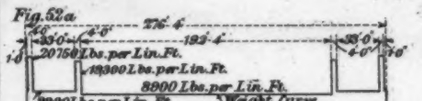
$$M c = \left(\frac{3\lambda^2}{L^2} - \frac{2\lambda^3}{L^3} - P \right) X + \frac{\lambda^2}{2L} \left(P + W \right) + \frac{P L}{2} - P \lambda - W_1 X_1.$$

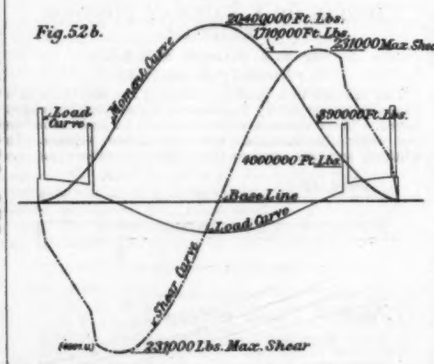












This may be written:—

$$M c = \left(\frac{3\lambda^2}{L^2} - \frac{2\lambda^3}{L^3} - P \right) X + \frac{P L}{2} - P \lambda + \frac{\lambda^2 W}{2L} - W_1 X_1.$$

The term $\frac{\lambda^2 W}{2L}$ is the moment of the buoyancy forces to the left of the point *c* about *c*, for the pontoon resting in still water. The term $W_1 X$ is the moment of the dead load to the left of the point *c* about *c*. The expression:—

$$\frac{\lambda^2 W}{2L} - W_1 X_1$$

therefore expresses the resulting dead-load moment at the point under investigation and should be considered separately. Omitting the terms representing the dead-load moment and giving P the special value 1, we have for the equation of the moment influence line for the assumed position of P:—

$$M c = \left(\frac{3\lambda^2}{L^2} - \frac{2\lambda^3}{L^3} - 1 \right) X + \frac{L}{2} - \lambda + \frac{\lambda^2}{2L} \quad . \quad (C)$$

When P is to the right of *c* and to the left of the centre of the bridge (Fig. 55*b*) the equation for moment at *c* is:—

$$M c = \left(\frac{3\lambda^2}{L^2} - \frac{2\lambda^3}{L^3} \right) X + \frac{\lambda^2}{2L} \quad (D)$$

When P is on the right half of the span (Fig. 55*c*):—

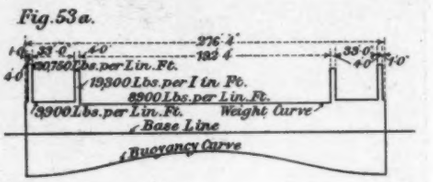
$$M c = \left(\frac{2\lambda^3}{L^3} - \frac{3\lambda^2}{L^2} \right) X + \frac{\lambda^2}{2L} \quad . \quad . \quad (E)$$

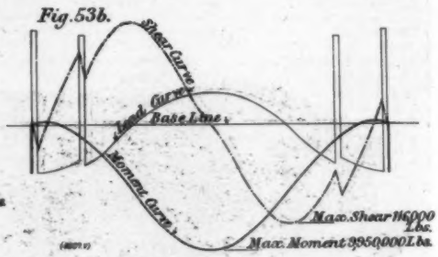
The shear at *c* when P is to the left of *c* is (Fig. 55*d*):—

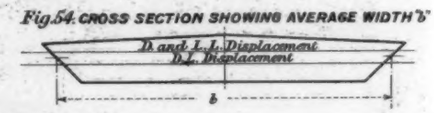
$$S = 62.5\, b \lambda \left(d_1 - \frac{d_1 - d_2}{L} \right) - P - W_1$$

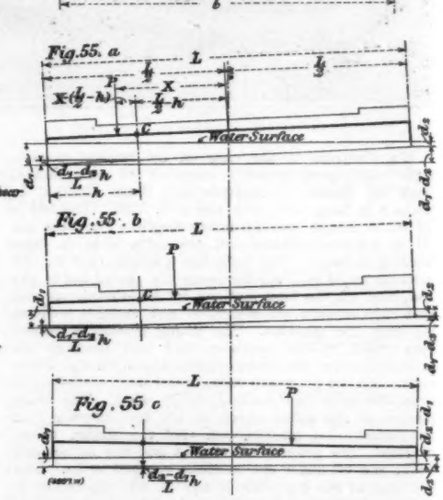
as before by substituting the values of d_1 and d_2 from A and B, reducing, eliminating the dead-load shear and giving the special value *l* to P, we obtain the equation of the live-load shear influence line at *c*:—

$$S = \left(\frac{6\lambda}{L^2} - \frac{6\lambda^2}{L^3} \right) X + \frac{\lambda}{L} - 1 \quad . \quad . \quad (F)$$









When P is to the right of *c* and to the left of the centre of the bridge the equation reads:—

$$S = \left(\frac{6\lambda}{L^2} - \frac{6\lambda^2}{L^3} \right) X + \frac{\lambda}{L} \quad . \quad . \quad (G)$$

When P is on the right half of the bridge we obtain in a similar manner:

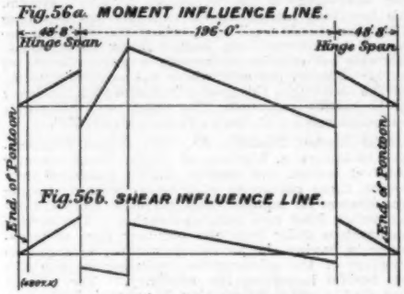
$$S = \left(\frac{6\lambda^2}{L^3} - \frac{6\lambda}{L^2} \right) X + \frac{\lambda}{L} \quad . \quad . \quad (H)$$

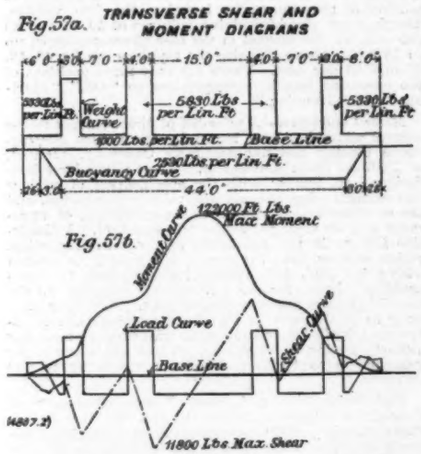
The moment and shear influence lines for the panel point L6 is shown in Figs. 56*a* and 56*b*. Between panel points L3—L3, the results are obtained by multiplying the wheel loads by the ordinates directly. Beyond these points the loads cannot be considered as acting directly on the pontoon, and the effect is found by multiplying the girder reaction at L3 by the ordinate directly below. The reaction at L3, of course, may be scaled off directly by laying off the influence line for the reaction at L3 as shown in the figures.

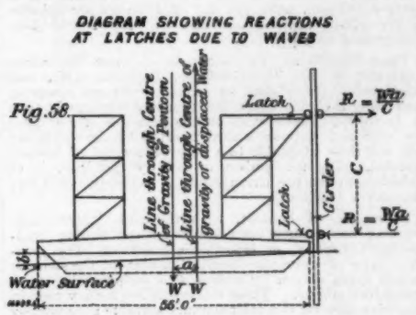
The forces producing stress in a transverse direction consist of the unbalanced dead and live load concentrations. The buoyancy and weight curves in a transverse direction for the pontoon resting in still water are shown in Figs. 57 *a* and *b*.

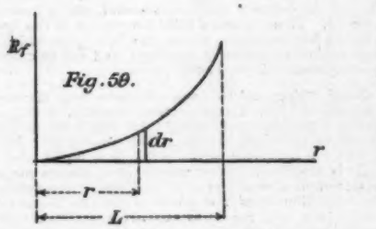
In case of rough weather with uneven water surface,

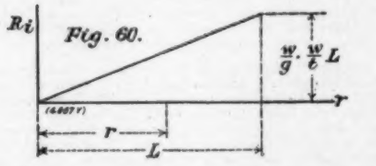
the transverse stresses are greater on account of wave action, and this effect is further increased by guiding the pontoon in a vertical plane as previously mentioned. In this case the difference in water level at the opposite sides of the pontoon is assumed 1 ft., and we then have the condition shown in Fig. 58. The weight of the volume of water displaced is still equal to the weight of the structure with its superimposed loads, but the centres of gravity of the two bodies no longer lie on the same vertical. This condition causes a moment which is resisted by the reactions on the vertical guides. For the assumptions made this reaction is about 75,000 lb. This stress is carried mostly in the vertical end frames, as owing to the comparative flexibility of the top horizontal lateral truss, only a small amount is carried to the adjoining vertical frames. Owing to the peculiarity of this structure, impact stresses were eliminated except for the floor beams and hinge spans, where 20 per cent. of the live load were arbitrarily added to cover impact stresses. For proportioning the various











members of this bridge the following unit stresses were used :—

	Lb. per sq. in.
Tension in steel rods and bolts ...	16,000
Tension in timber	1,500
Bending in timber—extreme fibre stress	1,500

Compression in timber $1{,}500\left(1-\frac{L}{60\,D}\right)$ per sq. in.

Where L = length and D = least depth in inches.

	Lb. per sq. in.
Bearing perpendicular to the grain ...	400
Bearing parallel to the grain	1,500
Shearing parallel to grain	270
Longitudinal shear	170

The power for swinging the pontoon must be sufficient to overcome various resistances, the principal ones of which are :—

1. Resistance due to wind.
2. Resistance due to water friction.
3. Resistance due to inertia.

There are several additional factors involved in the theory of ship-propelling. This theory is based on experiments performed under entirely different conditions and are hardly applicable to the swinging of a pontoon.

The resistance due to friction is given by the formula :—

$$R = fsV^2,$$

in which s = wetted surface in square feet.
V = speed in knots.
f = a coefficient.

For smooth surfaces f is equal to 0.009; for rough surfaces twice as great.

As there are 3,600 seconds per hour and a knot means 6,080 ft. per hour, we have :—

$$V = v\frac{3600}{6080}$$

in which v denotes the velocity in feet per second, and

$$R = fs\left(V\frac{3600}{6080}\right)^2$$

Expressing this in terms of the angular velocity we have :—

$$R_f = fs\left(\omega r\frac{3600}{6080}\right)^2$$

Since $v = \frac{2\pi rn}{r}$ radians, n = number of revolutions per second, this may be written.

$$R_f = fs\left(2\pi rn\frac{3600}{6080}\right)^2$$

rearranging, we have

$$R_f = 4f_3P^2n^2\frac{3600^2}{6080^2}r^2$$

By considering the angular velocity constant n is constant and R_f and r are the only two variables in the equation—hence the resistance varies as the square of the radius.

By taking R_f and r (Fig. 59) as the axes of a rectangular co-ordinate system and letting dr represent a small increase in the radius, we have for a corresponding increase in the resistance : Rdr and the total resistance is, setting

$$4fs\pi^2n^2\frac{3600^2}{6080^2} = C.$$

$$R_f = C\int_0^L r^2dr = \frac{1}{3}CL^3.$$

The centre of gravity of this area is located at a distance from the origin and is obtained by taking moment about the origin O. We then have

$$\frac{r}{3}CL^3 = C\int_0^L r^3dr = \frac{1}{4}CL^4$$

and $r = \frac{3}{4}L$.

The distance from the pivot pier to the pulling chain is 15/16L, and the power to be applied at the chain to overcome the friction therefore is

$$\frac{\frac{1}{3}CL^3 \times \frac{3}{4}L}{\frac{15}{16}L} = \frac{4}{15}CL^3 - - - - = P_f$$

To this frictional resistance should be added the friction due to the velocity of the stream when the bridge is operated against it. The velocity of the river at this point is approximately two knots and the resistance is :

$$R_v = fsV^2,$$

which may be considered constant without sensible error. The resultant of this force is applied at the centre of the bridge, and the chain pull will be

$$fsV^2\frac{\frac{1}{2}L}{\frac{15}{16}L} = \frac{8}{15}fsV^2 - - - - = P_v$$

The resistance due to inertia may be determined with sufficient accuracy by assuming the mass of the structure concentrated at a line through the centre of the pontoon. We then have

$$R_1 = MA.$$

in which M is the total mass,
A is the acceleration,
R_1 the resistance due to inertia.

The resistance due to inertia at the hinge point is 0 The resistance due to inertia at the lock end is

$$R = ma = \frac{w}{g}\cdot\frac{v}{t}$$

where w = weight per lineal foot of bridge.
v = linear velocity in feet per second.
g = the constant 32.2 due to gravity.
t = time of acceleration.

Expressing this relation in terms of the angular velocity ω we have, since $v = \omega r$:—

$$R = \frac{w}{g}\cdot\frac{\omega r}{t}.$$

This equation represents a straight line, and the total resistance is obtained by integrating the expression $\frac{w}{g}\cdot\frac{\omega}{t}r$ between the limits L and O, from which we obtain

$$R_1 = \frac{1}{2}\cdot\frac{w}{g}\cdot\frac{\omega}{t}L^2 = C_1L^2$$

which is the area of a triangle with base L and height $\frac{w}{g}\cdot\frac{\omega}{t}L$. (Fig. 60.)

The centre of gravity of this triangle is located at a distance 2/3 L from the origin, and the force at the chain required to overcome this inertia is

$$C_1L^2\frac{\frac{2}{3}L}{\frac{15}{16}L} = \frac{32}{45}C_1L^2 - - - - = P_i$$

The resultant of the resistance due to wind is applied at the centre of the structure, and its magnitude varies with the exposed surface and the velocity and direction of the wind. Assuming a wind pressure of P pounds per square foot of exposed surface, we have $R_w = PA$, where A is the exposed surface. The force at the operating chain to overcome this resistance is

$$PA\cdot\frac{\frac{1}{2}L}{\frac{15}{16}L} = \frac{8}{15}PA - - - - = P_w$$

The total force required at the chain to overcome the various resistances is

$$P = P_f + P_v + P_i + P_w;$$

of these three forces P_w varies with the velocity. P_i varies with the acceleration; if, therefore, the required maximum velocity is fixed and also the time of acceleration to reach this velocity is decided upon, the chain pull becomes a known quantity and the horse-power required can be determined.

To determine the power required for swinging the 276 ft. 4 in. pontoon just described, it was assumed that it should swing open in three minutes. Fixing one-half minute for accelerating, one-half minute for retarding, and constant velocity over two minutes, we have for the maximum velocity

$$2v + \frac{v}{2}\cdot\frac{1}{2} + \frac{v}{2}\cdot\frac{1}{2} = 400 \text{ ft. and } v = 160 \text{ ft. per minute.}$$

The 400 ft. represents the amount of chain passing over the drum during one opening of 90 deg., and for the acceleration we have

$V = a \times t$, from which a = 320 ft. per minute.

Substituting this velocity in the formula previously developed and assuming the wind pressure at 5 lb. per square foot, it was found that the force P at the chain sums up to about 9,000 lb. The horse-power required, assuming the efficiency of the machinery to be 65 per cent., is

$$HP = \frac{9000 \times 160}{0.65 \times 33000} = 67.$$

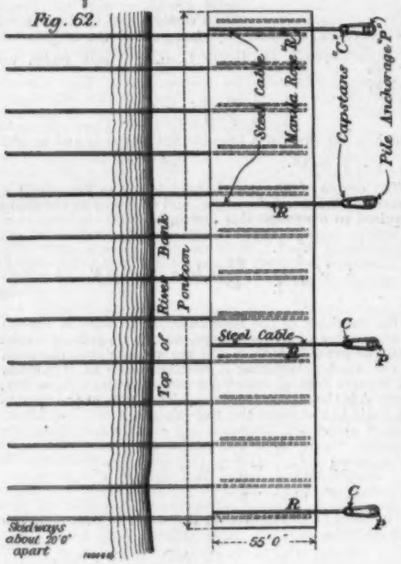
The pontoons are built on shore and launched before the floor and machinery is erected. The location of the construction platform and yard is shown in the map on Fig. 1, page 92 *ante*. Mr. N. Gregory, chief carpenter in charge of the construction, used the following method of launching the Prairie du Chien pontoon. The pontoon was built on a platform located near the east shore of the Mississippi River. When the pontoon was completed for launching, skidways were built about 20 ft. apart, as shown in Figs. 61 and 62. These skidways were built on a slope of 1½ in. in 12 in., and extend out into the river supported on piles cut below the surface, so that the pontoon is practically floating before it leaves the skidways. These skidways were lined with strips of hardwood on the top to provide a smooth sliding surface. Hardwood blocks about 8 ft. long were placed at suitable intervals to act as bearing blocks between the skidways and the pontoon. Above the pontoon, at the side

farthest away from the shore, four capstans marked "C" in Fig. 61 are placed in front of piles marked "P." The capstans are securely tied to the piles by cables or chains. Steel cables, shown in Figs. 61 and 62, were thrown around the pontoon and connected to the capstans. At the centre of the deck of the pontoon short pieces of manila rope, marked R in the figures, are inserted between the steel cables. The cables between the capstans and the pontoon are then tightened as much as possible to keep the pontoon from sliding before it is resting on all the skidways. The bents or cribs upon which the pontoon was built are then undermined, so that the pontoon gradually settles to a full bearing on the skidways. When a full bearing of the skidways has been obtained and everything is ready, a man with an axe is stationed on the deck of the pontoon at each cable. At the signal given by the man in charge,

SKETCH SHOWING METHOD OF LAUNCHING

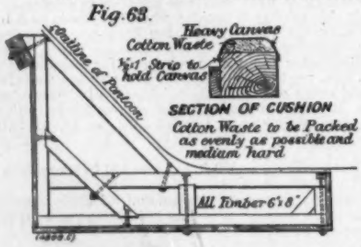
Fig. 61. CROSS SECTION

Fig. 62.



DRY DOCK USED FOR REPAIRING PONTOONS

Fig. 63.


Heavy Canvas
Cotton Waste
Strip to hold Canvas
Outline of Pontoon
SECTION OF CUSHION
Cotton Waste to be Packed as evenly as possible and medium hard
All Timber 6"x6"

the four pieces of manila rope inserted between the steel cables are cut simultaneously by these men and the pontoon slides slowly into the river.

Fig. 63 shows the dry-dock used in repairing these pontoons. It consists of timber frames lined with sheathing. The edge of this dry-dock is made to fit the outside of the pontoon and is lined with heavy canvas and cotton waste to make the joint between the dry-dock and the pontoon as water-tight as practicable. It is, of course, impossible to make this dry-dock entirely water-proof, and provision must be made for pumping the water constantly while the men are working in the dock.

The design of the west channel pontoon just described was in direct charge of the writer, under the direction of Mr. H. C. Lothholz, Engineer of Design, and Mr. C. F. Loweth, Chief Engineer of the Chicago, Milwaukee and St. Paul Railway.

Estimates for a concrete structure were made and compared favourably with the estimates for the wooden structure, but on account of the greater difficulties in construction and the comparatively shallow water during most of the season, the project was abandoned. A concrete pontoon would weigh considerably more than a timber structure, and consequently the greater displacement would require either a wider or a deeper structure. It would seem, however, that at certain locations a concrete scow used as a pontoon bridge should prove both economical and efficient and be worthy of consideration.

CATALOGUES.

Ironmongery.—Messrs. Nicholls and Clarke, Limited, of 5, High-street, Shoreditch, London, E., have sent us an abridged catalogue of the class of goods which they are supplying for military camps, such as stoves, cooking ranges, ironmongery, lavatory fittings, paints, oils and glazing. They point out that on account of the abnormal fluctuation of the market, it is impossible to give prices in the publication, but are, of course, pleased to give quotations on receiving inquiries.

Bolt and Nut Machines.—We have received a catalogue of bolt-threading and nut-tapping machines from the Webster and Perks Tool Company, of Springfield, Ohio, U.S.A. This gives illustrations of machines with from one to six spindles, capable of threading bolts up to 1¼ in. in diameter at a rate equivalent to some 4,000 ½-in. bolts per day of 10 hours per spindle. A five-spindle tapping machine will tap 20,000 ¾-in. hot-pressed nuts per day.

Time Recorders.—The Gledhill-Brook Time Recorders, Limited, of 26, Victoria-street, London, S.W., and Huddersfield, have sent us some leaflets and a reprint describing their machines for recording workmen's time in factories. These work on the principle of stamping the time and date on a card inserted by the employee, and are thus adaptable to a very wide range of costing systems. The mechanism, which, by the way, is of British manufacture throughout, is strongly made and practically fool-proof.

Conveyors.—A booklet, with the title "Meco Conveyors," has recently been issued by the Mining Engineering Company, of Moorfields, Sheffield. The principal type of conveyor described is that of the shaking trough type, driven by means of a reciprocating compressed-air engine. These conveyors are largely used in English collieries, but are naturally suitable for a variety of other purposes. The engine has an adjustable stroke, so that it may be regulated to work economically whether the delivery is up or down-hill, and is unusually compact. There is also a brief description of the Spence noiseless face conveyor, one of the belt type, which will work against quite heavy gradients, and can be operated by compressed air or electric power.

Oxy-Acetylene Blow-Pipes.—Messrs. A-L Meteorlite, Limited, of 106, Victoria-street, London, S.W., have sent us a pamphlet describing their dissolved acetylene system of blow pipe welding. The outstanding feature is that the acetylene is dissolved in a liquid and this liquid is absorbed, under pressure, in a fibrous material contained in a seamless steel cylinder. Acetylene in this condition does not come under the Home Office Regulations with regard to explosives, and thus may be handled quite freely, while its convenience, as compared with the gas generated on the spot by means of a portable plant, needs no emphasising. The booklet includes price lists of all the apparatus necessary for oxy-acetylene welding and cutting, besides compressed gases.

Industrial Lighting.—A booklet advocating the Holophane system of industrial lighting has been sent to us by Messrs. Holophane, Limited, of 12, Carteret-street, Queen Anne's-gate, London, S.W. TheHolophane electric light reflectors are too well known to need description, but it should be pointed out that those manufactured for industrial purposes have an aluminium sheath spun over the glass. This not only reduces the liability to breakage, but also greatly facilitates cleaning. The prismatic reflecting surfaces are completely sealed, and thus do not tarnish. The booklet contains a quantity of useful information concerning the scientific illumination of factories and gives particulars of the principal types of Holophane reflectors.

Steam-Pipe Expansion Joints.—The "Doust" expansion joint for steam pipes has now been on the market for several years, and was described in Engineering some time ago, but even now it does not enjoy the vogue it deserves. The construction of the device is described in a pamphlet recently issued by the makers, and engineers troubled with leaky ranges of long steam pipes should write to Messrs. Doust's Patent Expansion Joint Company, Limited, of 21, Great St. Helens, London, E.C., for particulars. The broad principle of the joint is the substitution of two steam-tight sliding sleeves for the usual gland packing, and the fact that the P. & O. Steam Navigation Company have adopted it for all new ships shows that it can be relied upon to perform its functions.

Foot-Power Presses.—Messrs. Perkin and Co., Limited, of Whitehall-road, Leeds, send a couple of leaflets dealing with bench millers and foot-power presses. The former are handy little machines suitable for the general work of a small shop, or the small work of a general shop, and appear to be good value for the modest price demanded. They will machine flat surfaces up to 8 in. by 5 in. The presses are of the pendulum and treadle patterns. The first will perform heavier work than is usually expected from this type of tool. It will, for instance, punch a ½-in. hole through ⅛-in. metal. The treadle press is not quite so powerful, but it is exceptionally adaptable in the way of length of stroke and leverage. Either of these machines will give an output of from 15,000 to 20,000 pieces a day, when working on plain blanking.

Rotary Planers.—From the Newton Machine Tool Works, Incorporated, of Twenty-third and Vine-streets, Philadelphia, U.S.A., we have received a catalogue of rotary planing machines. This company manufacture a number of other types of machine tool, but they have developed the rotary planer, especially as regards its use in structural workshops, to a high degree of perfection. The illustrations, which are representative of over 200 installations, show that the machines are substantially constructed, and thus chatter, which might affect the quality of the output, is avoided. The standard cutter heads have diameters ranging from 26 in. up to 100 in., and have longitudinal feeds of 5 ft. and 8 ft. respectively. Some of the machines are mounted on circular bases, so that angular facings may be worked on conveniently.

Ventilating Plant.—The Sturtevant Engineering Company's "Treatise No. 1240," which has just been published, is the first they have issued dealing exclusively with ventilation, and is of topical interest, now that so many factories are working at high pressure both day and night. Several different systems of ventilation, such as exhausting, forced circulation and combined circulation and exhaust methods, are described; but the most noteworthy is the "Cold Air Douche" system. This has been introduced for such services as rolling mills, glass bottle works, &c., where the workmen are exposed to intense local heat. Ducts are arranged with wide bell-mouths, to provide a gentle current of cool air right on the spot where the men are at work, and the claim that this greatly increases their efficiency will be readily conceded. The Sturtevant Company's London address is 147, Queen Victoria-street, E.C.

Motor Starters, Switches, &c.—The British Thomson-Houston Company, Limited, of Rugby, have recently published several new leaflets, among which we may mention those concerned with hand-operated starting compensators for squirrel-cage induction motors, iron-clad switch fuses and isolating switches. The starting compensators differ from the ordinary type of transformer in having the secondary winding arranged as a portion of the primary, thus reducing the size and cost, besides increasing the efficiency. The current taken by the motor, on starting, is reduced, in the proportion of the square, by lowering the line voltage. Tappings are provided giving voltages of 50, 65 and 80 per cent. of the normal in the case of compensators up to 18 h.p. Above this size the tappings are for 40, 58, 70 and 85 per cent. There are only three positions of the operating handle, corresponding to "Off," "Starting" and "Running."

Motor Controllers.—A price-list of direct-current motor control pillars has been issued by the British Westinghouse Electric and Manufacturing Company, Limited, of Trafford Park, Manchester. These pillars have been designed to comply with the specification of various Government departments and railway companies, and are so devised that almost any combination of apparatus can be arranged in the one standard. A distinctive feature is the automatic field accelerating relay, which ensures that the motor will always be started with a full field, but automatically weakens the magnetising current, for the purposes of speeding up the machine, to any predetermined extent. The same company have also sent us a leaflet describing their hand-operated liquid controllers for use with slip-ring reversing motors, driving haulages, &c. These are suitable for voltages up to 3,300 and rotor currents up to 750 amperes.

Well-Boring Plant and Gravel Pumps.—Messrs. Werf Conrad, of Haarlem, Holland, and 39, New Broad-street, London, E.C., have sent us an elaborate catalogue of well-drilling plant for prospecting or the actual exploitation of oil, gas fields, &c. For the oil drilling rigs the improved Canadian system has been adopted, with combinations of the cable and water-flush systems. For limited depths a light portable plant is offered, which can be arranged to work as a rotary or core drill. Motive power is provided by a steam engine, oil engine or electric motor, according to the local facilities. The derricks, up to 66 ft. high, are steel structures hydraulically riveted. The catalogue, which is noteworthy on account of the excellence of its illustrations, includes practically everything required in sinking a borehole. Another publication from the same company deals with their "Stannum" gravel pump for alluvial mining and dredging. In this pump the liners usually fitted to take the erosion of the sand are dispensed with. The casing is in one piece and of such a simple form that it is more economical to wear it out and scrap it rather than replace liners. The impeller is inserted through the enlarged discharge orifice. Special leather and wood rings are fitted to prevent sand getting into the gland, and the weight of the shaft is carried by roller bearings. Particulars are given for pumps from 4 in. up to 15 in. in diameter, together with a cable code for spare parts. The makers claim that in the case of an 8-in. pump their design effects a saving in weight of 1½ tons over the usual type of lined pump.

An Indian Railway Conference.—The annual session of the Indian Railway Conference has just been held at Simla. Mr. Bell, agent of the Eastern Bengal Railway, has discussed with the Indian Railway Board the question of the Siliguri and Santahar conversion scheme, on which the Government of India will report shortly to the Secretary of State for India in Council. Sir Robert Highett, agent of the East Indian Railway, has also been in Simla in connection with the question of the renewal of the East Indian Railway contract which is now before the Government of India. This involves the general subject of State as opposed to company management, on which it is safe to say that no decision can be arrived at until local governments and other bodies have been consulted.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

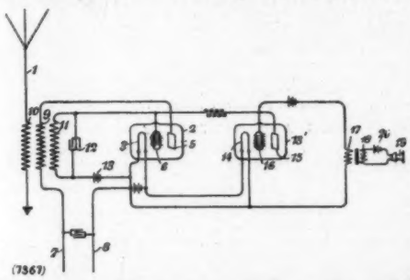
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

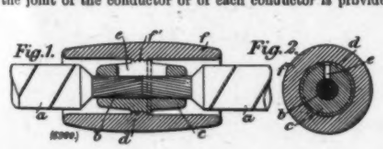
ELECTRICAL APPARATUS.

7,367/15. The British Thomson-Houston Company, Limited, London (*General Electric Company, Schenectady, U.S.A.*) **Wireless Signalling Systems.** (1 *Fig.*) May 17, 1915.—This invention relates to means for controlling the transmission of wireless signals. A wireless signalling system having means for producing oscillations in an antenna comprises, according to this invention, an electron discharge device and a second electron discharge device connected to the grid circuit of the first device to control the amplitude of oscillations set up in the antenna. The electron discharge device 2 comprises a



cathode 3, an anode 5, and a controlling grid 6 operatively connected to an antenna 1 and arranged to produce continuous electrical waves therein. The second electron discharge device 13l consists of a cathode 14, an anode 15 and a controlling grid 16, the cathode and anode being connected respectively to the cathode and controlling grid of the first discharge device 2. A telephone transmitter 19 is used for varying the potential of the controlling grid in the second electron discharge device 13l. (*Sealed.*)

6,980/15. A. E. Tanner, Stretford, and E. A. Claremont, High Legh. Electric Cable. (2 *Figs.*) May 10, 1915.—In joining two sections of an electric cable it is usual to place over the two ends to be joined a longitudinally slit metal sleeve (hereinafter referred to as the ordinary sleeve) and to pour over the whole molten solder, which flows through the slit, permeates the spaces between the separate strands and between the conductor and the sleeve, thus making a solid connection. According to this invention, an outer metallic casing enclosing the whole of the joint of the conductor or of each conductor is provided.



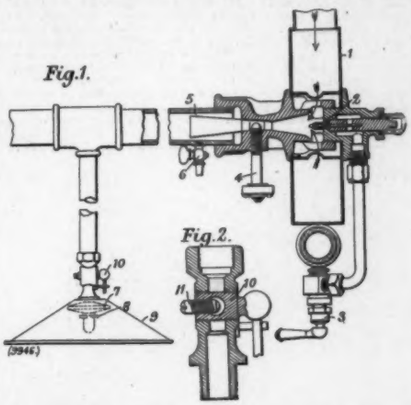
This casing, which is hereinafter called the outer sleeve, is connected to, and is therefore at the same potential as, the ordinary sleeve and the conductor. *a* is the insulated conductor, *b* the bared conductor, *c* the ordinary sleeve with a threaded collar *d* and the slit *e* to admit solder; *f* is the outer sleeve with a threaded part *f1* to connect with the collar *d* of the ordinary sleeve. When the outer sleeve is in position over the joint of the conductor, or of each conductor, if there be more than one, the whole joint is encased in a box which is filled with insulating compound or is insulated in any other known manner. (*Sealed.*)

10,762/15. The British Thomson-Houston Company, Limited, London, and A. A. Pollock, Rugby. Dynamo-Electric Machines. (3 *Figs.*) *July* 24, 1915.—The invention relates to dynamo-electric machines having commutating poles. This invention consists in reducing the axial length of the commutating pole near the armature by cutting away one or more portions between the ends of the pole. Fig. 1 shows diagrammatically the manner in which flux leakage takes place from the commutating pole-piece 1 to the adjacent main poles 2, the working flux at the pole face being only about one-third of that carried by the back portion of the pole near the frame of the

machine. The difference between these two values is the leakage flux, and this has an undesirably high value. The greater part of this leakage takes place in the main pole tips. By cutting out a portion of the commutating pole between the ends at the face of the pole without altering the cross-section at the back near the frame of the machine a very considerable reduction in leakage can be effected. In carrying the invention into practice, the axial length of the commutating pole face is reduced by cutting a portion of the face nearest the armature away; for example, by cutting a V-shaped or channel-shaped portion 3 or 4 respectively out of the pole-piece between the ends of the pole, as shown in Figs. 2 and 3. Instead of cutting away a single portion, it will be obvious that the same result could be obtained by cutting a number of smaller portions away. (*Sealed.*)

GAS-ENGINES, PRODUCERS, HOLDERS, &c.

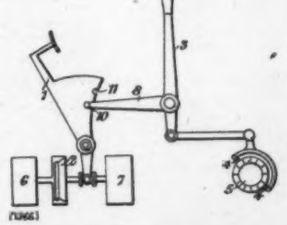
9,946/15. J. Keith and G. Keith, London. High-Pressure Gas Lighting. (3 *Figs.*) July 8, 1915.—The system of high-pressure gas lighting according to the present invention comprises a pipe line along which is distributed a series of burners, a single injector for supplying a self-burning mixture to the pipe line, an air-duct in communication with the injector and extending to a zone of fresh-air supply, and controlling means for the mixture, the injector and controlling means being located within the building in which the burners are working. The injector device, which is conveniently coupled to the air-duct 1, is so mounted that the gas nipple 2 may be readily removed for inspection and cleaning. Outside the duct 1, but within the place in which the burner or burners is or are working, are fitted a cock 3 for controlling the gas supply, and a regulating screw 4,



the latter being disposed transversely of the Venturi tube 5 and adjustable to regulate the quality of the mixture. The pet-cock 6 affords a means of judging the quality of the mixture when the regulating screw 4 is adjusted. Each burner of the series may comprise a heater 7, to which is connected a nozzle and with which may be associated a simple reflector 9; cocks, one of which is provided on each lamp fitting, serving for cutting off individual burners when desired and for controlling the quantity of mixture taken by each burner, so that the burners may be balanced *in situ*, as will be understood. The cock employed comprises in the instance shown a plug 10 screwed through the body of the tube sustaining the lamp, said plug being fitted with a check screw 11 for choking the bore. (*Accepted May* 31, 1916.)

MOTOR ROAD VEHICLES.

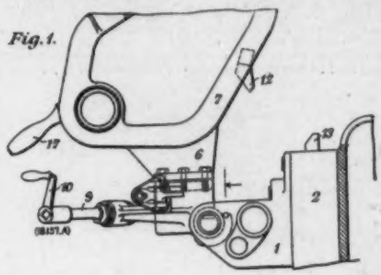
7,366/15. The Daimler Company, Limited, F. W. Lanchester and J. L. Milligan, Coventry. Petrol-Electric Drive. (4 *Figs.*) May 17, 1915.—This invention relates to automobile vehicles in which an electric generator is coupled directly to the internal-combustion engine so as to rotate therewith, the shaft of the electric generator being capable of connection to or disconnection from the shaft of an electric motor by means of a clutch, the shaft of the electric motor being employed to drive the vehicle so that the vehicle can be driven through the medium of the direct clutch mechanism from the internal-combustion engine, and when this direct gear is thrown out of action by disengaging the clutch the intermediate electrical transmission may be brought into action for the purpose of driving the vehicle

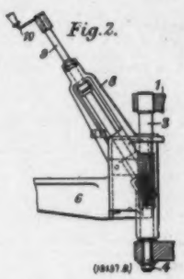


at lower speeds and also for preliminary transmission of power when acquiring speed prior to driving the vehicle direct from the internal-combustion engine. According to the present invention, in order to render the driving of the car standard—that is to say, so that any driver can take charge without calling for the exercise of special skill—safety arrangements are provided to prevent the clutch being put into operation while the electrical transmission is operative, and therefore the invention consists in the operation of a lever 3 for regulating the proportion of torque between the dynamo 6 and the electric motor 7, in combination with a lever for controlling a clutch 2, the two levers directly interlocking and co-operating to prevent the clutch being brought into operation except when the intermediate electrical transmission is inoperative. (*Sealed.*)

PRINTING AND ALLIED MACHINERY.

18,157/15. Lanston Monotype Corporation, Limited, London. (*Lanston Monotype Machine Company, Philadelphia, U.S.A.*) **Type-Casting Machines.** (4 *Figs.*) December 30, 1915.—This invention relates to type-casting machines wherein the molten metal is contained in a melting pot which must be capable of vertical movement into and out of its operative position as well as a swinging movement whereby it may be turned off to one side so as to give access to the mechanism and to the parts immediately associated with the melting pot itself. The present invention provides a simple and convenient form of mechanism for raising and lowering the melting pot, which may be manipulated by the attendant while standing on the front side of the casting machine, and without requiring him to stoop in order to effect the raising and lowering movements. The invention comprises a raising and lowering mechanism for the melting pots of type-casting machines embodying a vertical shaft 3 mounted in fixed supports 1 and

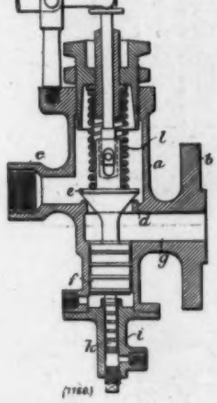




having teeth or a rack thereon, a melting-pot support 6 mounted to slide vertically on the shaft 3, a second shaft 9 journalled in bearings in the melting-pot support to move vertically therewith and having an operating handle 10 at the upper end at one side of the pot, and a toothed gear connected with or mounted on the last-mentioned shaft to be rotated thereby and engaging the teeth on the first-mentioned shaft. (*Sealed.*)

PUMPS.

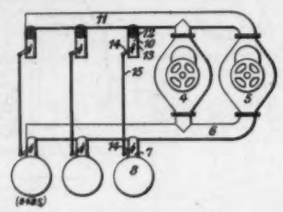
7,760/15. Worthington Pump Company, Limited, London, and E. O. Rodaway, Balderton. Pressure Relief Valves. (2 *Figs.*) May 25, 1915.—This invention relates to pressure relief valves of the type in which the valve itself is in complete equilibrium or balance by means of a piston in conjunction with said valve, and is adapted to be operated by an auxiliary piston connected with the main, the pressure in which is to be controlled. The invention consists in a pressure relief valve of the type referred to, comprising a valve *d* controlled by a spring *e*, a piston



f in conjunction with the valve *e*, and an auxiliary piston *h* in combination therewith and communicating with the main in which the pressure is to be controlled, the arrangement being such that at normal pressure the valve *d* is in complete balance by reason of the pressure of the spring *a* and the pressure on the piston *f* balancing the pressure on the valve *e* and on the auxiliary piston *h*, and is operated to relieve any excess of pressure by the increased pressure acting on the auxiliary piston against the pressure of the spring. (*Accepted May* 31, 1916.)

8,485/15. The British Thomson-Houston Company, Limited, London. (*General Electric Company, Schenectady, U.S.A.*) **Centrifugal Compressors.** (2 *Figs.*) June 8, 1915.—The present invention relates particularly to means for preventing pulsation at light loads. This invention finds particular application in installations where a single compressor, or a plurality of compressors operating in parallel, furnish air to a main blast conduit from which leads a series of branch blast pipes. In such apparatus it is often desirable to shut off one or more of the units, and in accordance with this invention an arrangement is provided wherein whenever any unit is shut off the inlet to the compressor or compressors is throttled, or the effective area thereof diminished by a corresponding amount. To this end, the inlet conduit of the compressor of a header is provided with a plurality of branches through which the air is drawn, and preferably there will be as many branch inlet pipes as there are branch discharge pipes. Each branch inlet pipe and branch discharge pipe is also provided with a suitable valve,

and the valves in the discharge pipes are each connected with a valve in an inlet pipe, so that they will both be operated simultaneously. By this means it will be seen that whenever a branch discharge pipe is shut off, to disconnect a producer unit, for example, one of the branch inlet pipes will also be closed off. This means, then, that the effective area of the inlet conduit of the compressor or compressors is always proportional to that of the discharge conduit and pulsation will be effectively prevented. 4 and 5 indicate two centrifugal compressors connected in parallel to the common discharge conduit or header 6. Leading from the discharge conduit are a plurality of branch discharge pipes 7, which lead to any suitable points of consumption 8, for example,



gas producers. In each of the branch pipes is a suitable valve. The compressors receive air through the branch inlet pipes 10, connected in parallel to the header or conduit 11. In each of these branch pipes is a suitable hand valve 12 and a suitable valve means as a butterfly valve 13. In the present instance three branch discharge pipes are illustrated and there are a corresponding number of branch inlet pipes. The valves in the discharge pipes are each connected to a valve 13, as through the operating arms 14 and rods 15. By this arrangement, whenever a rod 15 is moved to close one of the valves in a discharge pipe, the corresponding valve 13 will also be closed. (*Accepted May* 31, 1916.)

RAILWAYS AND TRAMWAYS.

7,774/15. G. H. Williams and E. S. Luard, London. Locomotive Feed-Water Heaters. (6 *Figs.*) May 25, 1915.—This invention relates to feed-water heating apparatus for locomotive boilers. The invention consists principally in the combination, with a boiler provided with the usual safety valve or valves for relieving excessive pressure of steam directly to the atmosphere and having a feed-water storage tank, of an automatically operating surplus steam-valve device for passing surplus steam to the feed-water tank, comprising a valve casing having an inlet port communicating with the steam space of the boiler and an outlet port, a valve seat at the inlet port, and a valve in the casing adapted to seat at the valve seat, and so loaded that when a predetermined boiler pressure, always lower than that at which the safety valve or valves is or are set to open, is exceeded, said valve will open and admit live steam from the boiler, through the valve casing and a pipe connected to the outlet port thereof, to the water in the feed-water tank to heat such water, until the boiler pressure is reduced to the predetermined pressure. 1 is the loaded valve which comprises a valve-casing 3, open at one end to a port in the back-plate 2,

Fig. 1.

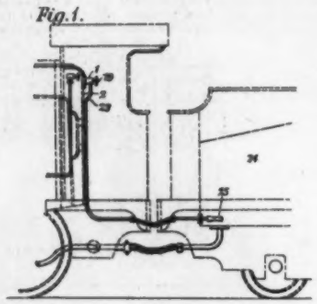


Fig. 2.

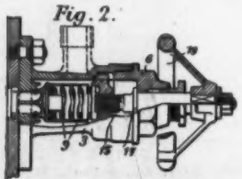
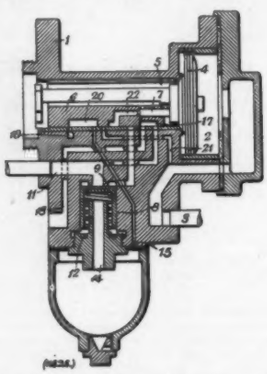


Fig. 3.

and therethrough to the steam space of the boiler, a valve seat being provided adjacent this end of the casing 3. The outer end of the casing 3 is closed by a screw cap 6. Within the casing 3 a poppet valve is arranged to seat on the valve seat. An adjustable compression spring 9 is arranged between the poppet valve and an abutment in the valve casing 3. The valve casing 3 is provided with a port leading to a pipe 23 communicating with the feed-water tank 24 and terminating in a fitting 25, the passage of steam through which causes a circulation of the water in the tank. In this fitting the steam pipe 23 is connected to a central jet 26 which projects into, and is held in place in, an outer tube 27. The outer tube is double coned, the most constricted portion of the tube being a short distance in front of the discharge end of the central jet 26, and the inducing cone being open at its wider end 28 to the water in the tank. The steam rushing through the central jet 26 draws water through the open rear end 28 of the surrounding cone and propels same forwardly, the said water condensing the steam and being at the same time heated by the steam. The setting in motion of water by the steam jet causes a circulation or movement of the body of water in the tank. (*Accepted May* 31, 1915.)

11,626/15. The Westinghouse Brake Company, Limited, London. Brakes. (2 *Figs.*) March 24, 1915.—This invention relates more particularly to fluid-pressure braking apparatus adapted to secure a more uniform brake action in an emergency or full-service application of the brakes. The invention consists in a valve device adapted upon a reduction in the train pipe pressure to permit an intermittent supply of fluid under pressure to the brake cylinder. The valve device comprises a casing 1 having a piston chamber 2 connected to the train pipe 3, and containing the usual triple valve piston 4, a valve chamber 5, open to the usual auxiliary reservoir and containing the main slide valve 6 and graduating valve 7. The flow of fluid from the auxiliary reservoir to the brake cylinder is controlled by a valve piston 8 adapted in one position to cut off communication between a supply passage and the brake cylinder passage 11, and in another position to open said communication. A vent chamber communicates with the underside of the valve piston 8 and with the seat of the main slide valve 6. In operation, the triple valve piston being in normal release position as shown, fluid from the train pipe charges the auxiliary reservoir in the usual manner, and the brake cylinder is open to exhaust. The chamber 13 is at atmospheric pressure. When a reduction in the train pipe pressure is made, the triple valve piston 4 is moved to the application position, which is the same for both service and emergency applications, except that under a gradual reduction in train-pipe pressure, as, for instance, in the case of a leakage from the train pipe, the triple valve piston will move the slide valve only far enough to establish communication between the auxiliary reservoir and the brake cylinder to such an extent that the rate



of reduction in the auxiliary reservoir pressure by flow to the brake cylinder will substantially equal the rate of reduction in the train-pipe pressure. The movement of the slide valve 6 towards the application position first opens communication between the train pipe and the vent chamber, so that a local reduction in train-pipe pressure is effected. Further movement of the slide valve allows fluid from the auxiliary reservoir to flow to the exposed area of the piston 8. The pressure in the vent chamber is at this time lower than the auxiliary reservoir pressure, so that the piston 8 will be forced from its upper seat, to allow the flow of fluid to the brake cylinder. The vent chamber being still connected to the train pipe, the pressure therein will now reduce with the train-pipe pressure; but since the auxiliary reservoir pressure drops very quickly by expansion into the brake cylinder, the pressure in the vent chamber will soon exceed that acting on the opposite side of the piston. The piston 8 will in these circumstances be forced to its upper seat, cutting off further flow of fluid to the brake cylinder. As the reduction in the train-pipe pressure continues, a point is reached where the pressure acting above the piston again exceeds the pressure in the vent chamber, when the piston 8 will again open to permit further flow of fluid from the auxiliary reservoir to the brake cylinder. In the same manner the piston 8 continues to intermittently open and close during an application of the brakes, and by this means a very gradual build-up of brake-cylinder pressure is obtained without the necessity of employing a small supply passage. (*Accepted May* 31, 1916.)

STEAM-ENGINES, BOILERS, EVAPORATORS, &c.

6011/15. J. P. O'Donnell and H. E. Geer, London. Pressure Relief Valves. (3 *Figs.*) April 21, 1915.—This invention relates to pressure relief valves for use in connection with engine cylinders, and consists primarily in providing means whereby, should any failure in the proper working of the valve arise, due, for instance, to failure of the live steam supply for holding the valve in its closed position, the valve can be mechanically

Fig. 1.

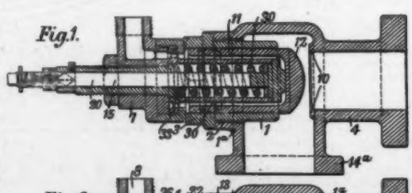
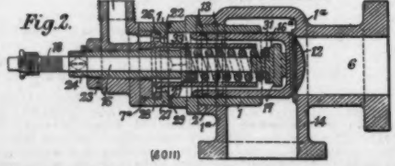


Fig. 2.



moved into and yieldingly held in its closed position in such a manner that, although the valve will not then perform its normal functions, should excess pressure of a predetermined degree arise in the engine cylinder, such pressure will force the valve off its seat, thus giving the necessary relief and consequently avoiding possible damage to the cylinder end. The valve casing comprises two main portions 1, 1a. The portion 1a is provided with a tubular extension 4, whereby the valve device can be secured to the cylinder end with the duct 6 in alignment with the relief port in the cylinder end; 7 is a head piece screwed into the portion 1, the head piece having formed in it the ports 8 and 9 for the admission of live steam to the interior of the valve casing for moving the release valve 11 on to the valve seat 10 at the inner end of the duct 6. The tubular branch 14 of the valve casing is connected to the usual by-pass pipe, which is connected to the pressure release valve at the opposite end of the engine cylinder. With the parts in the position shown in Fig. 1 the valve 11 will act as an automatic excess pressure release or relief valve when the engine is running or working with steam on, and as a compression release or relief valve when the engine is running with steam shut off; that is to say, when the engine is running with steam on live steam admitted through ports 8 and 9 acts on the outer side of the valve 11 and holds it on the seat 10, *i.e.*, in the closed position, shutting off communication between the release port in the cylinder end and the by-pass pipe or atmosphere (through the tubular part 14 of the valve casing) as the case may be. Under these conditions, should excessive pressure (above that of the live steam acting on the valve 11 to hold it closed) arise in the engine cylinder, due, for instance, to priming, such pressure will act on the valve 11, and move it off its seat 10, into the position shown in Fig. 1 (*i.e.*, the open position), so that the pressure will be relieved or released through the passage 6 and tubular branch 14, after which the live steam acting on the outer side of the valve 11 will move it on to the seat, thus again closing the valve, which will remain closed until excessive pressure again arises in the engine cylinder. Should any failure arise in the working of the valve, as above described, due, for instance, to the failure of the live steam supply through the ports 8 and 9, the valve can be mechanically moved into and yieldingly held in its closed position by screwing in the sleeve 20 until the parts take the position shown in Fig. 2, in which the valve 11 is held on the seat 10 (*i.e.*, in the closed position) by the head 16 on rod 15 against the action of the spring 30, which is compressed to the desired or predetermined extent. Under these conditions, should such a degree of pressure arise or be set up in the engine cylinder as might cause damage to the cylinder end, such pressure will overcome the pressure of the spring 30, and the valve will consequently be forced off its seat, thus relieving the pressure. The valve 11 thus acts as a simple spring-loaded pressure release or relief valve. (*Sealed.*)

SHIPS AND NAUTICAL APPLIANCES.

7,324/15. W. Chadburn, Bournemouth, and Chadburn's (Ship) Telegraph Company, Limited, Bootle. Ship's Telegraph. (4 *Figs.*) May 15, 1915.—This invention has reference to apparatus for communicating between one part of a navigable vessel and another, and it relates more particularly to apparatus for communicating between the engine, room and the stokehold of a ship. The object is to provide mechanism for an oil-heated steam-generating power plant, comprising a telegraphic apparatus provided with means adapted to transmit and indicate through a single transmitting instrument, a single receiving instrument, and a single-motion transmission means, for each position, the degrees of pressure required, and the burners or numbers of heating units on a boiler required. 1 is the hand-actuated wheel of the transmitter; 2 is the shaft which it is mounted on, and which revolves when worked; 3 is the pointer or indicator; and 10 is the dial over which the pointer works. This pointer is mounted on the hub of a notched

Fig. 1.

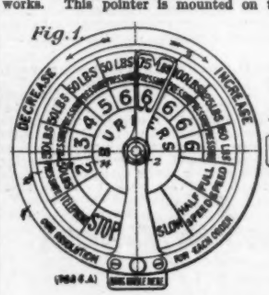


Fig. 2.

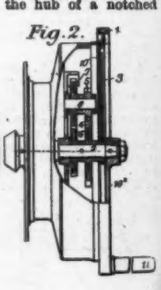
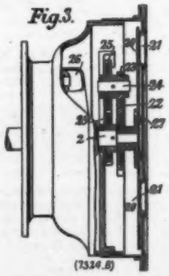


Fig. 3.



wheel 4, loosely mounted on the shaft 2, and actuated by a single toothed wheel 5, driven from the shaft 2 by a toothed pinion 6 on it, and a toothed pinion 7 on the spindle 8, with which is connected the single toothed wheel 5; by this gear the pointer is moved suddenly a fraction of the revolution made by the wheel 1; and this fraction is equal to the pitch part of the order fields of the dial 10. The wheel 1 consists of a rim and a single spoke 10*x*, at the outer end of which the actuating handle 11 is fixed. In the receiver instrument, the indicating means consists of a rotary disc dial 20, bearing upon it all the orders marked on the dial 10, and two windows 21 in an opaque face-plate 27 in front of the indicating dial. The indicating dial 20 is mounted loosely on the terminal of the shaft 2, and has connected with it a notched wheel 22, operated by a single toothed wheel 23, mounted on the pin 24, and driven from the shaft 2 by the two spur pinions 25, one of which is fixed on the shaft 2, and the other is connected to the wheel 23. (*Accepted May* 17, 1916.)

American Unfinished Steel.—Exports of steel ingots, billets and blooms from the United States to Europe have assumed large proportions. In the last quarter of 1915 they averaged 50,942 tons per month, but in the first four months of this year they have reached an average record of 84,770 tons per month.